Aircraft Inspection

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AIRCRAFT INSPECTION

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PREFACE

The material presented in this book is the result of practical experience over a number of years. Much of this experience the author acquired while a member of the inspection division of the Douglas Aircraft Company, Inc., at Santa Monica, Calif.

The material is general in nature. Questions of design and technical details are intentionally omitted in order to increase the scope of usefulness of this book. The material is arranged so as to promote easy reference.

There is no intention of superseding or changing the principles laid down by any manual published by any manufacturer. The information issued by each factory must at all times be considered the authority for the personnel of that factory.

The author earnestly hopes that this book will contribute to the success of aircraft inspectors and mechanics, whether they are active in the factory or in maintenance.

Grateful acknowledgment is expressed for the courtesy and cooperation extended by the following:

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ERNEST E. WISSMAN.

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AIRCRAFT INSPECTION

CHAPTER I

INSPECTION

The last thing an airplane does is fly.

Preparations, tests, and inspections require skill and thorough knowledge to ensure a safe airplane being released for its first flight.

Aviation is not so much a business of machines as of men. The human element plays a vital part and must contribute a high degree of efficiency and skill.

Once the airplane has left the ground, its safety depends on the correct functioning of its mechanical components and on the mastery over it by the pilot at its controls.

The inspector charged with the duty of guaranteeing this mechanical safety has great responsibilities and must strive constantly to increase his knowledge in order to keep step with modern developments and changes.

Willingness to share his knowledge with production personnel, cooperation with all concerned, thoroughness in the tasks assigned him, constructive attitudes, loyalty to his employer—these are the characteristics of the true inspector.

1.1. Aircraft Inspection Is Safety Insurance and Quality Control. Quality in a product is not the result of accident; it is built into the product by diligent control, which extends into supplier's plants and continues through every step of the manufacturing process up to the finished product.

With respect to aircraft, from the engineer's blueprints to the flight itself, inspection is the management's guardian of the product manufactured. The inspection of aircraft is a highly technical profession. Experience in this field is the basis upon which to build a successful record of dependable inspection.

Owing to the intricate technical aspects of the modern airplane, it is necessary to specialize in the various branches of inspection. There are material, precision, assembly, installation, electric, radio, engine, propeller, and flight-operation inspectors. There are still others to inspect the development, testing, and research of airplane materials or airplanes with their equipment.

1.2. Personal Qualifications for Inspection. It is not only experience and technical knowledge that make an inspector but personality and the ability to get along with others. The harmonious atmosphere so vital to smooth-flowing production depends to a great extent on the inspector. His authority, properly used, is seldom questioned. Customer's representatives judge the efficiency and reliability of inspection by the inspection personnel assigned to their contracts. The position of inspector requires personal conduct at its best. His is a key position and a very responsible one in the production of modern aircraft.

1.3. Personal Relations in Inspection. The respect accorded members of the inspection department depends largely on their conduct among themselves and toward others. Loyalty to the employer and to the department is a basic requirement; cooperative and helpful attitudes are a tribute to the department.

If suggestions are in order, they should be offered in a constructive and impersonal way. When differences of opinions exist, it is best to refer them to a superior.

If an error or oversight has occurred, the responsibility for it should be accepted promptly. It is human to make mistakes, but it takes a man to benefit by them.

Information pertaining to inspection duties is confidential and should be considered as such when the work of the day is over.

Conditions warranting the special attention of a superior should be called to his notice and not discussed with others.

It is important that inspection records and reports be correct and factual; personal opinions should not enter into them. A well-written report is concise, correct, and, above all, legible. Handwriting difficult to read invites misinterpretation and consequent errors.

Entrance into an office should be made as quietly as possible in order to prevent disturbing others at work. Conversation should be conducted in a quiet voice, and the visit made as short as convenient.

For every profession and trade there is a code of ethics, and the inspection department is no exception to this rule. Individual members of the department should consider it their duty and responsibility to uphold this code by pursuing their assignments in a diligent and dependable manner.

CHAPTER II

AIRCRAFT BLUEPRINTS

2.1. Purpose of Blueprints. A blueprint is actually the engineer's written instructions to those planning, fabricating, assembling, and inspecting the individual part, which has been approved as a component part of the complete airplane. A blueprint must be considered a valuable instrument.

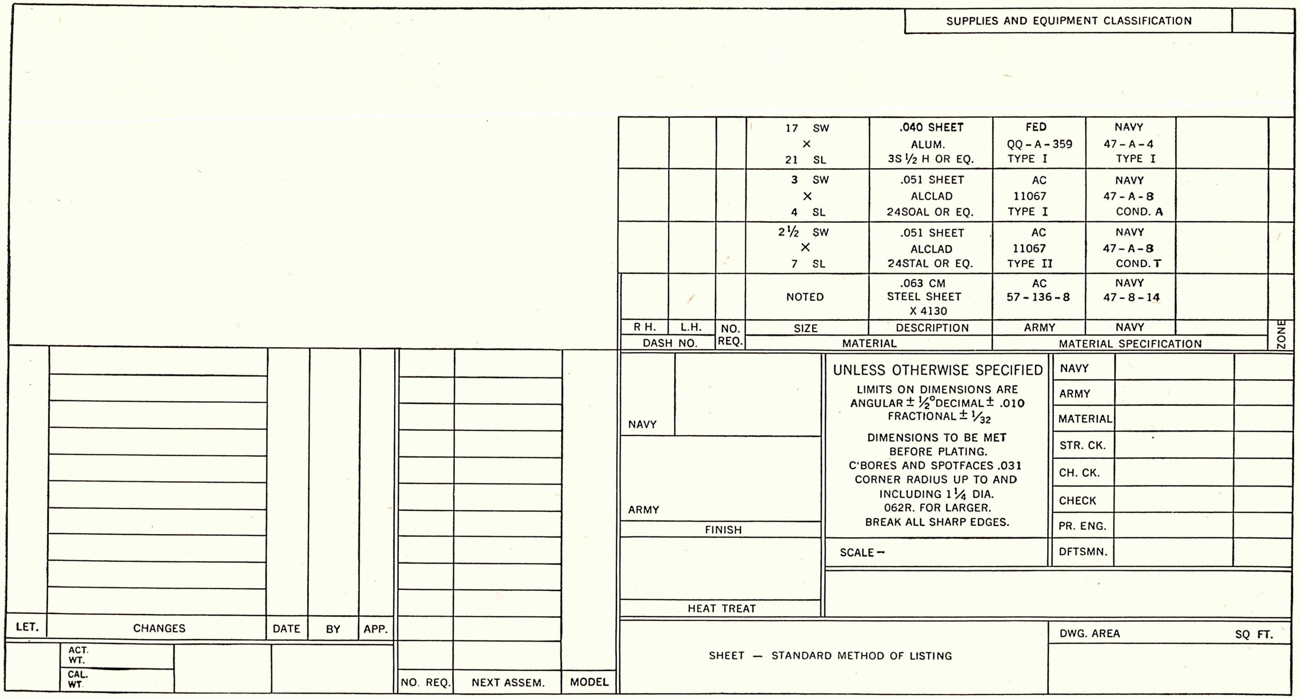
The modern blueprint process permits the duplication of any written or sketched matter in as many copies as desired, at a minimum cost, and with remarkable speed. Its development and adoption have proved a great help to firms engaged in manufacturing. Aircraft blueprints have been standardized to a high degree, but the engineering drafting manuals of the individual manufacturer should be considered the authority for prints produced by them.

The essential requirements for a working drawing are that complete information for fabrication of the parts be clearly and explicitly indicated and that parts shown thereon be so arranged and numbered that repair or replacement parts can be ordered and stocked without difficulty.

2.2. Information Given in Blueprints. All pertinent information in general is found in the Title Block which is located in the lower right-hand corner of the blueprint. This Title Block has Subtitle Blocks such as the Material Block, Dash-number Block, Specification Block, and Change Block. In addition, there are given information on the model of the airplane, the next assembly, and the number of parts required on the next assembly; a description of the article, assembly, or installation shown; and the identification number (see Fig. 1).

In the Material Block is found information on the type of material to be used and its required sizes, together with applicable Army, Navy, or commercial specifications.

The Dash-number Block contains a description of the dash numbers and the number of each required.



SUPPLIES AND EQUIPMENT CLASSIFICATION

DASH NO.			MATERIAL		MATERIAL SPECIFICATION			
R H.	L.H.	NO. REQ.	SIZE	DESCRIPTION	ARMY	NAVY		ZONE
			17 SW × 21 SL	.040 SHEET ALUM. 3S ½ H OR EQ.	FED QQ - A - 359 TYPE I	NAVY 47 - A - 4 TYPE I		
			3 SW × 4 SL	.051 SHEET ALCLAD 24SOAL OR EQ.	AC 11067 TYPE I	NAVY 47 - A - 8 COND. A		
			2½ SW × 7 SL	.051 SHEET ALCLAD 24STAL OR EQ.	AC 11067 TYPE II	NAVY 47 - A - 8 COND. T		
			NOTED	.063 CM STEEL SHEET X 4130	AC 57 - 136 - 8	NAVY 47 - 8 - 14		

NAVY

ARMY

FINISH

HEAT TREAT

UNLESS OTHERWISE SPECIFIED
LIMITS ON DIMENSIONS ARE
ANGULAR ± ½° DECIMAL ± .010
FRACTIONAL ± 1/32

DIMENSIONS TO BE MET
BEFORE PLATING.
C'BORES AND SPOTFACES .031
CORNER RADIUS UP TO AND
INCLUDING 1¼ DIA.
062R. FOR LARGER.
BREAK ALL SHARP EDGES.

SCALE –

NAVY
ARMY
MATERIAL
STR. CK.
CH. CK.
CHECK
PR. ENG.
DFTSMN.

SHEET — STANDARD METHOD OF LISTING

DWG. AREA SQ FT.

LET. | CHANGES | DATE | BY | APP.

ACT. WT.
CAL. WT.

NO. REQ. | NEXT ASSEM. | MODEL

FIG. 1.

The Material and Dash-number Blocks are combined with the Material Block adjacent to the right-hand side of the Dash-number Block.

The Specification Block includes information on standard limits, tolerances, finish, heat-treatment requirements, etc.

In addition to the information given in the above-named blocks, valuable and necessary information is often written in "general notes." These are usually located near the left-hand side of the Dash-number Blocks and must be taken into consideration in studying the blueprint.

To facilitate the locating of changes on a roll drawing (large type), the letters assigned to the change are found along the upper border of the blueprint, as nearly above the location of the change as possible.

It should be remembered that in some cases additional pertinent information may be found in detail sections or views when these are included.

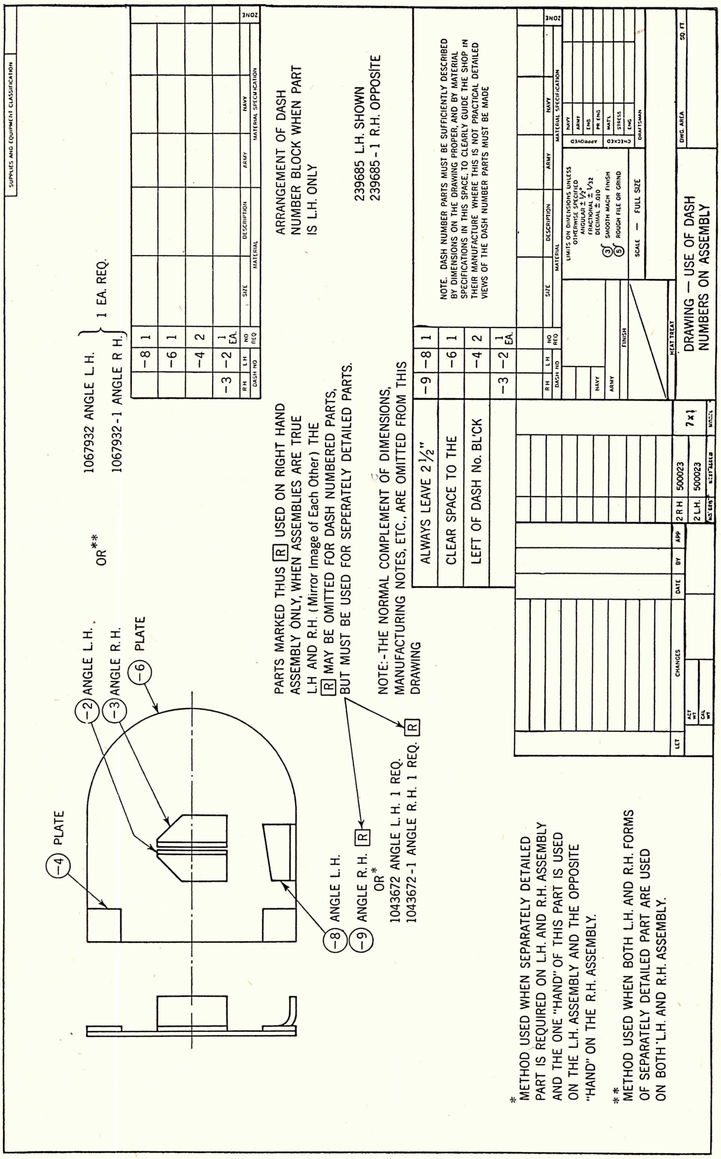
2.3. Assembly and Installation Blueprints. An assembly drawing shows two or more individual parts joined together to form a unit that may be installed on another assembly or in the airplane itself. Any assembly must be able to be stocked as a unit.

An installation drawing shows where and how parts and assemblies are installed in the airplane. There are two types, major installation blueprints and subinstallation blueprints. Major installation blueprints are used for all parts of a functional group in a definite section of the airplane, *e.g.*, fuselage fuel-system installations. Subinstallation blueprints are used to reduce the complexity of the major installations.

An assembly or installation drawing requiring a side view is always drawn as viewed from the left-hand side of the airplane headed toward the left.

Assembly and installation drawings having both left-hand and right-hand sides symmetrical and identical are drawn normally for the left hand. The fore or aft directions must be indicated and the note, "Symmetrical about center line" placed under the drawing center line. The left-hand location is expressed also as LH and the right-hand location as RH.

2.4 Dash Numbers. Dash numbers are numerals beginning with 1 and continuing in numerical sequence to the maximum


SUPPLIES AND EQUIPMENT CLASSIFICATION
–4 PLATE
–2 ANGLE L.H.
–3 ANGLE R.H.
–6 PLATE
–8 ANGLE L.H.
–9 ANGLE R.H. R
OR*
1043672 ANGLE L.H. 1 REQ.
1043672-1 ANGLE R.H. 1 REQ. R
OR**
1067932 ANGLE L.H.
1067932-1 ANGLE R H.
1 EA. REQ.
R H
L H
DASH NO
NO REQ
SIZE
MATERIAL
DESCRIPTION
ARMY
NAVY
MATERIAL SPECIFICATION
ZONE
–3 –2 1 EA.
–4 2
–6 1
–8 1
–9 –8 1
ARRANGEMENT OF DASH NUMBER BLOCK WHEN PART IS L.H. ONLY
239685 L.H. SHOWN
239685-1 R.H. OPPOSITE
ALWAYS LEAVE 2½" CLEAR SPACE TO THE LEFT OF DASH No. BL'CK
NOTE. DASH NUMBER PARTS MUST BE SUFFICIENTLY DESCRIBED BY DIMENSIONS ON THE DRAWING PROPER, AND BY MATERIAL SPECIFICATIONS IN THIS SPACE, TO CLEARLY GUIDE THE SHOP IN THEIR MANUFACTURE WHERE THIS IS NOT PRACTICAL DETAILED VIEWS OF THE DASH NUMBER PARTS MUST BE MADE
LIMITS ON DIMENSIONS UNLESS OTHERWISE SPECIFIED
ANGULAR ± ½°
FRACTIONAL ± 1/32
DECIMAL ± .010
3 SMOOTH MACH FINISH
5 ROUGH FILE OR GRIND
SCALE – FULL SIZE
APPROVED
CHECKED
DRAFTSMAN
STRESS
HEAT TREAT
FINISH
ARMY
NAVY
DRAWING – USE OF DASH NUMBERS ON ASSEMBLY
DWG. AREA
SQ. FT
LET
CHANGES
DATE
BY
APP
ACT WT
CAL WT
2 R H 500023
2 L.H. 500023
7 x 1
NXT ASSEM

PARTS MARKED THUS R USED ON RIGHT HAND ASSEMBLY ONLY, WHEN ASSEMBLIES ARE TRUE L.H AND R.H. (Mirror Image of Each Other) THE R MAY BE OMITTED FOR DASH NUMBERED PARTS, BUT MUST BE USED FOR SEPERATELY DETAILED PARTS.

NOTE:-THE NORMAL COMPLEMENT OF DIMENSIONS, MANUFACTURING NOTES, ETC., ARE OMITTED FROM THIS DRAWING

*METHOD USED WHEN SEPARATELY DETAILED PART IS REQUIRED ON L.H. AND R.H. ASSEMBLY AND THE ONE "HAND" OF THIS PART IS USED ON THE L.H. ASSEMBLY AND THE OPPOSITE "HAND" ON THE R.H. ASSEMBLY.

**METHOD USED WHEN BOTH L.H. AND R.H. FORMS OF SEPARATELY DETAILED PART ARE USED ON BOTH L.H. AND R.H. ASSEMBLY.

FIG. 2.

numeral required. They are used for identification purposes on blueprints and are prefixed with a dash to distinguish them from all other numerals on the blueprint, *e.g.*, -1, -2, -3, etc. Each dash number is placed near the part or piece it identifies and is enclosed within a circle, having an arrowed extension line touching a border of the part or piece concerned (see Fig. 2).

Dash numbers are used to designate the LH and RH parts of a detail or assembly.

They are used to indicate the subparts of an assembly that can be sufficiently described on the assembly without the necessity of separate detail drawings for each piece.

They are used to indicate the coding and/or tabulating of parts that are basically identical but that vary in one or more dimensions or details and are covered by a single drawing.

2.5. LH and RH Parts. In all airplane structures, there are many parts that are manufactured in both LH and RH forms. This does not mean that one assembles on the LH side of the airplane and the other on the RH side. Instead, the RH form is a mirror image of the LH form, with the relative positions of all portions of the part reversed.

Both the LH and the RH form of a part may assemble on the same side of an airplane. The LH form is shown on the blueprint and the RH form is identified by a "-1" of the basic drawing. For example, "5061379LH shown. 5061379-1RH opposite."

Whenever minor differences exist between LH and RH parts or assemblies, separate views on the same drawing show the affected portion of the RH part or assembly. These views are titled to indicate clearly their nature and location, as "View A-A, cutout in -3 Web, Zone 4."

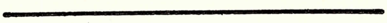
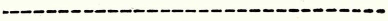
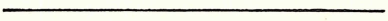
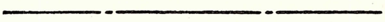
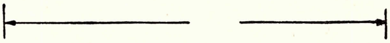
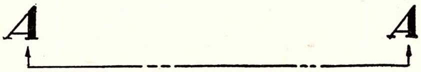
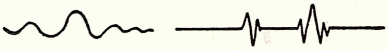
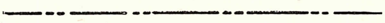
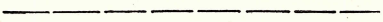
Installation drawings are not assigned LH and RH part numbers unless they assemble on an LH and an RH assembly.

Power-plant installations and subinstallations are assigned separate part numbers (dash numbers), because the engine is not LH and RH and requires an unsymmetrical installation. The drawings usually show the LH side only. For example, "LH side shown. RH side opposite and/or as noted."

If the installation is truly symmetrical between LH and RH, the LH only is shown. If not truly symmetrical, the LH and RH sections are shown separately.

2.6. Reading a Blueprint. The only successful method of reading any blueprint is the systematic method. The first thing to read in looking at an open blueprint is the number and description of the article represented.

ALPHABET OF LINES

OUTLINE OF PART		The part outline should be the outstanding feature of the drawing and the thickness of the line may vary to suit the size of drawing.
HIDDEN OUTLINES		A line made up of short dashes.
CROSS SECTION LINES		Light line, spaced to give the drawing a shaded effect.
CENTER LINES		Broken line, made up of long and short dashes.
DIMENSION & EXTENSION LINES		Light lines, unbroken except at dimensions.
CUTTING PLANE		Broken line, made up of one long and two short dashes.
BREAK LINES		Freehand lines for short breaks. Ruled lines and freehand zig-zag for long breaks.
ADJACENT PARTS		Broken line, made up of one long and two short dashes.
LINES OF MOTION OR ALTERNATE POSITION		Light broken lines made up of long dashes.

Next, check the model affected, the latest change letter, and the next assembly listed. Then proceed to read the general notes and the contents of the Material Block. Determine the location of each dash number by consulting the zone locations.

Check and find the various changes incorporated on the blueprint, and carefully read all special information given near or in views and sections, such as information on the type of rivets, bolts, and other fasteners or special notations.

When the blueprint applies to several models, be careful to refer frequently to the information given in the general notes. Symbols will be given there that will indicate which sections of the blueprint apply only to given models.

Pay close attention to the location of laps and skin joints, doublers, openings, cutouts, rivet spacing, type and size of rivets, and the material requiring heat-treatment, such as formed sheets. Notes on blueprints calling for parts to match, etc., are most important and should always be given careful attention.

Information on dimensions and special tolerances is given so that certain design requirements may be met. This information should always be carefully noted.

Likewise of vital importance are the specialized methods of locking and safetying, for which directions are given on some prints.

2.7. Special Information Given in Blueprints. On hydraulic-tubing installations, certain lubricants are called for. Blueprints for doors, cockpit installations, etc., will contain notes specifying special cements for waterproofing purposes and others. When notes call for parts to be installed in later productive operations, they must not be overlooked; and when assembly consists of parts that are called for by their respective part-number drawings, it is a wise policy to check these drawings for any pertinent information given.

2.8. Identifying an RH Part. Some blueprints have the notation "LH Shown; RH Opposite," indicated by a "-1." On such blueprints, sometimes it is most difficult to visualize the picture of the opposite, or "-1," assembly. One way to overcome this difficulty is to hold the print against the light and look at its aft side, keeping the blue-colored side toward the light. The outline of the lines on the blueprint will then show the RH part.

2.9. Large Installation Blueprints. On installation drawings such as the blueprints for fuselage plating, several sections of the airplane may be shown, such as the left-hand side, right-hand side, and top and bottom views. These views and sections may be shown separately or combined. When reading such a blueprint, familiarize yourself with one of these four items before going to the next; otherwise, confusion and misunderstanding are likely to result.

This is especially important on tubing installation blueprints. In these, at times a certain dash-numbered tubing seems to disappear entirely; yet when a close check is made, this tubing may be shown on one of the other sections.

2.10. Control-cable Blueprints. When tracing control cables on an installation drawing, follow one cable through its entire routing. Become familiar with all information pertaining to it, and then proceed to the next cable. Be careful when following cable routings, and do not relax your vigilance, though the task may be somewhat difficult. Ascertain by all means the sizes of cables and turnbuckles and their locations and types, and the material of which safety wire is made. Refer to drawings, the AN Standard Parts Book, or the company standard parts book whenever such parts are called for. Practice the reading of blueprints whenever the opportunity presents itself.

The following rule must be borne in mind, in addition to the need for a systematic procedure: Don't hurry the reading of a blueprint. No matter how experienced one may become, it still is necessary to be careful when reading a blueprint.

2.11. Reference Blueprints. Reference blueprints are generally in use in the engineering division and the lofting and experimental departments and are marked "Reference Print."

Reference blueprints are intended primarily for use as "consultation" prints, not as actual reproductions of an article to be made, and are not for use in production.

These blueprints show proposed outlines and design features that have to be proved definitely by the production of material replicas of the pictured idea. They give locations, dimensions, and other pertinent information for parts or installations affecting and relating to consecutive assemblies. The reference blueprints, with reference to cables, wiring, and tubing, give approximate stock lengths, but not definite length dimensions. Such prints will bear a note "Actual length to be determined on first ship, and dimensions forwarded to the Engineering Department."

On installation reference blueprints, the location, attachments, and routing of tubing and cables are shown approximately, and the outline of the airplane and the portion of it covered by the blueprint is shown in phantom lines. Necessary corrections are indicated by production with the cooperation of the engineering department. These corrections, after careful checking, are incorporated in future production blueprints.

All this can be summed up by saying that reference blueprints are used for the most part on new or experimental models or when major redesigning is proposed for a model already existing. It must be borne in mind in using these blueprints that caution must be observed in the use of the information given and that all dimensions should be double-checked before the blueprint is marked.

When changes or information is entered on such reference blueprints, the name of the person making the change must be given, together with the date.

2.12. Production Blueprint. A production blueprint is an exact copy of the part, assembly, or installation that the engineering department desires to have made.

On these blueprints is given all the detailed information needed to produce, assemble, or install a part or a combination of parts. Minor changes found necessary during production are incorporated on the production blueprint by changing lines, dimensions, or information in ink. Major changes are made by canceling the original drawings and making entirely new blueprints and drawings, incorporating all previous minor changes. This is done by the engineering department.

2.13. Keeping Records of Blueprints. When new drawings have been made and blueprints based on these are available, the old and canceled blueprints are removed from the files in the respective production departments, destroyed, and then replaced by the new, up-to-date blueprints. All records kept on available and existing blueprints are also brought up-to-date by members of the blueprint-distribution department.

2.14. Specific Engineering Information. In addition to the regular blueprints issued by the engineering department, specific information is issued for development, for experimental purposes, or to correct errors by production. The form used may be identified as a "project sketch," "engineering memo," a "special engineering order," etc.

2.15. Care of Blueprints. A blueprint is expensive to produce. The expense incurred for material and labor, from the very beginning to the finished product, must be realized by everyone handling or using them.

The care used in handling blueprints by personnel is a reflection of their interest and pride in and knowledge of their profession.

The opening of a folded blueprint, if improperly done, can result in damage and tearing. The paper used for blueprints is very stiff when new; therefore, the folds of the paper should be opened carefully and slowly. After opening, the folds should be smoothed out, but they should not be bent opposite to the original folds, for this will make the closing of the blueprint difficult.

When folding, take time and care, so as not to make new folds near the original ones. The size of a folded blueprint is established for filing in a standard-size cabinet.

Do not lay an open blueprint on a surface that is littered with screws, rivets, etc., for such objects may tear or make holes in the paper.

Do not lay tools or other objects on a blueprint; for they will soil the print surface, making it unsightly and more difficult to read.

Hands should be clean, in using a print, for dirt and grease will produce an illegible and unsightly condition.

Notations or remarks should not be made on a blueprint. They not only are misleading and confusing but may be considered by others as new information and may thus prove responsible for a misunderstanding. Only authorized members of the engineering division should make such notes or changes. They will then see that a special-colored ink is used, the change signed, and the date indicated. It is important that such notations be complete, for initials and undated changes cannot be considered as authentic.

When a blueprint no longer is needed, it should be folded carefully and correctly, then filed away for future use. If time does not permit returning the print to the files immediately, it is better to retain it in one's possession. The filing, however, should be done at the first opportunity.

Blueprints should always be filed with care. Carelessness nullifies the effectiveness of a system that has been adopted to preserve the condition of the completed print and make it immediately available for reference.

2.16. Drawing Blueprints from the Files. When blueprints are to be withdrawn from the files, the person wanting the print must use a blueprint charge card. When a blueprint is no longer needed, it is returned to the files. Blueprints are vital and are kept for the exclusive use of members of the department; therefore, it is most important that these files be kept in order. Anyone removing a blueprint from these files should leave a correctly made-out charge card in the place of the removed print.

The sequence of numbers in which blueprints are usually filed should not be disturbed.

When new blueprints are issued, it will be easy to remove obsolete blueprints and replace them.

The order and manner in which blueprint files are kept in the various departmental files are an indication of the attitude of the entire personnel.

2.17. Lost Blueprints. The loss of a blueprint must be considered a serious matter. Every precaution should be taken to prevent such losses.

Besides the temporary lack of information perhaps most urgently needed at the moment, it must be realized that somebody may be charged with the missing blueprint.

Any loss should be reported immediately.

To avoid the embarrassment associated with losing a blueprint, the best advice is—not to lose one.

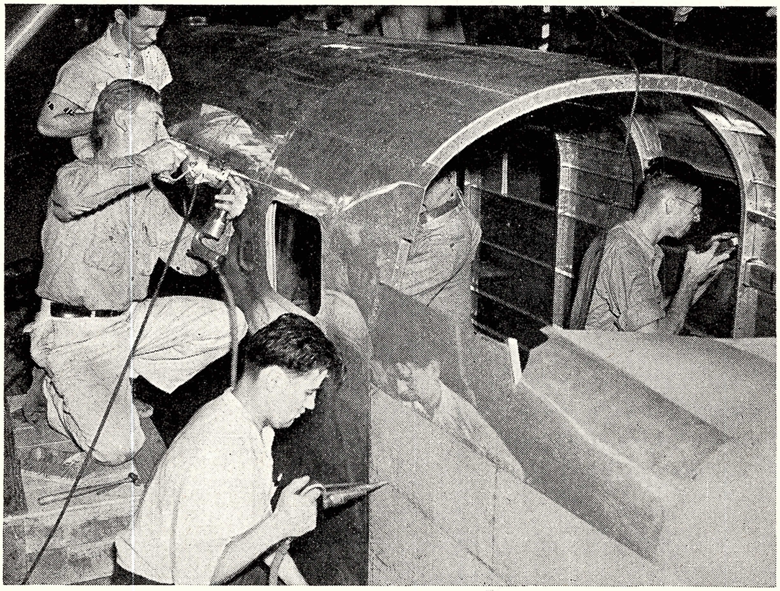
2.18. Value of a Blueprint. Consider a blueprint as a costly and valuable instrument to be used in assisting you in your work.

A blueprint is an indispensable source of information and a valuable instrument to anyone active in or associated with the manufacture of aircraft.

CHAPTER III

STANDARDS OF WORKMANSHIP FOR RIVETING

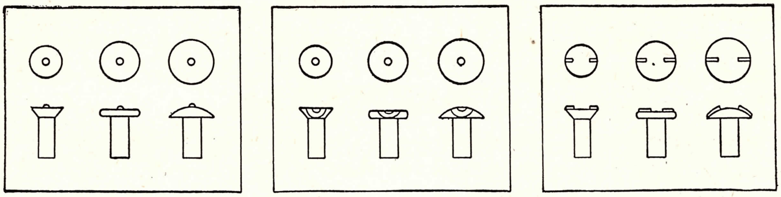
3.1. Introduction. One of the major operations in building the modern airplane is riveting. Riveting is the most satisfactory method of joining aluminum and its alloys. Aluminum alloy rivets are employed where maximum resistance to corrosion and weight saving are essential.



Riveting on Lockheed Model 12 fuselage. (*Courtesy of Lockheed Aircraft.*)

3.2. Identification of Rivets. The riveting in aircraft construction is limited to the smaller sizes and is usually done cold. Identification markings have been adopted for use on the heads of aircraft rivets of the following alloys: 17S, A17S, and 24S. These markings are illustrated below (Fig. 3). No identification marks have yet been adopted for rivets of other alloys.

Rivets of alloys 17S, A17S, and 24S are supplied with an anodic coating, if such a coating is specified. This coating



Type D Alloy 17S Heat treat before using. Minimum shear 30,000 p.s.i.

Type AD Alloy A17S Do not heat treat. Minimum shear 25,000 p.s.i.

Type DD Alloy 24S Heat treat before using. Minimum shear 35,000 p.s.i.

FIG. 3.

improves the resistance of the rivets to corrosion and also provides a better surface for painting.

3.3. Types of Rivets. Owing to the large number of various types of rivet now in use in aircraft construction, a description is given here of the more commonly used types and their uses, together with the system of coding, to aid in reducing the amount of confusion that now exists.

Rivets are made of various kinds of material and in various styles of head. The Army and the Navy have agreed on certain kinds, which are known as conforming to AN standards. Tabulated below are the rivets most commonly used. The numbers identify style of head, the letters kind of material. Rivets are completely identified as to style of head, material, diameter, and length, by coding. In the table below, only style of head and material are listed.

Style of head	Aluminum (3S), no heat-treatment	Aluminum alloy (A17S), no heat-treatment	Aluminum alloy (17S), heat-treatment	Aluminum alloy (24S), heat-treatment
100° Countersunk head....	AN426	AN426AD	AN426D	AN426DD
Round head..........	AN430	AN430AD	AN430D	AN430DD
Flat head............	AN442	AN442AD	AN442D	AN442DD
Brazier head.........	....	AN455AD	AN455D	AN455DD

1. Aluminum (3S) rivet. This rivet has no mark on the head but has a raised numeral 3 on the end of the shank. It is never used in primary structures.

2. Type AD, depression in head, aluminum alloy (A17ST) rivet. This rivet does not further age-harden at room tempera-

ture and is purchased ready for use. AD rivets are not approved for general Navy work and may be used only when specifically called for on drawings.

3. Type D, raised tit on head, 17ST aluminum alloy rivet. These rivets age-harden rapidly at room temperature and are kept in iceboxes which retard the hardening. Best riveting can be accomplished within 15 min. after removal from the icebox, but rivets can be satisfactorily driven up to ½ hr. exposure to room temperature.

4. Type DD, raised double dash on head, aluminum alloy rivet. Minimum shear 35,000 p.s.i. Heat-treat before using. Obtain from the icebox only enough for 5 min. use. On the 3/16- and ¼-in.-diameter rivets, it is recommended that only two or three rivets be taken from the icebox at a time. Before driving DD rivets, leadmen should be contacted on the best method of installation. These rivets are so hard that they will crack or enlarge the hole if not properly driven.

Special attention is drawn to the length of time during which icebox rivets may be used after removal from icebox. Return all unused rivets and those out for a longer period than specified to the container provided on the outside of the icebox. Rivets must never be replaced in the icebox. *The only way rivets can be returned to the soft condition is by reheat-treatment.*

The completed formed head of the rivet should be 1½ times the diameter across and ½ the diameter in height. The correct length of rivet needed to form this head can be found by experiment. The thickness of material through which the rivet is driven and the size of the hole governs this length.

3.4. Coding of Rivets.

AN	455	DD	5 -9	= Type DD Brazier	5/32 in. dia. × 9/16 in. long
AN	426	D	3 -14	= Type D Countersunk	3/32 in. dia. × 7/8 in. long
AN	430		2 -6	= Type A Round	1/16 in. dia. × 3/8 in. long
AN	442	AD	4 -5	= Type AD Flat	1/8 in. dia. × 5/16 in. long
AN	430	D	3 -4	= Type D Round	3/32 in. dia. × ¼ in. long
AN	455	AD	6 -7	= Type AD Brazier	3/16 in. dia. × 7/16 in. long
AN	426	DD	8 -22	= Type DD Countersunk	¼ in. dia. × 1⅜ in. long

└Lengths in sixteenths.
└Diameter in thirty-seconds.
└Alloy of rivet.
└Type of head.
└Army, Navy standard part.

3.5. Driving of Rivets. A properly driven rivet will have a uniform upsetting throughout the length of the shank. To accomplish and facilitate this, the rivet sets must have smooth and polished surfaces, so as not to hinder the flow of metal during the riveting operation. A rough surface will mark the heads of rivets and may cause a rivet to be so unsightly that it will have to be replaced. The selection of the bucking tool is of great importance. It must be of sufficient weight to buck up the rivet properly, and it should have a smooth and polished surface at the point of contact. Its shape and form should be adapted to the special job on which it is used. It is good practice to radius all corners and edges and to tape over such radii to prevent damage resulting from the bucking tool slipping during the riveting operation. The cup on the rivet set should be neither too large nor too small. If too large, damage will occur to the metal surrounding the rivet head. If too small, ringing of the rivet-head will result (see Fig. 4).

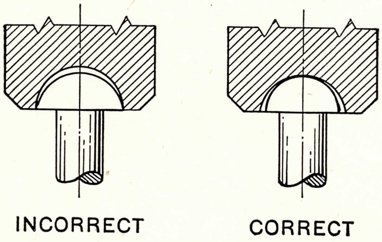


Fig. 4.

3.6. Driving Pressure for Rivets. The pressure required to drive a rivet depends upon the size and type of rivet and the driving temperature. Excessive pressure in driving may result in bulging, buckling, distorting, weakening, or fracturing the material. Overdriving of rivets should always be avoided.

3.7. Rivet Holes. Rivet holes in aluminum alloy materials are drilled, punched, or counterpunched. The clearance permitted in the holes depends on the type of work involved. When rivets are driven cold, a small clearance is desirable. If a loose fit is used, it will be difficult to hold the rivet straight and an eccentric head may result.

3.8. Alignment of Rivet Holes. The alignment of rivet holes is exposed to change during the driving operation due to slipping or swelling of the metal. For this reason, the work must be assembled firmly to guard against slipping of the material and to prevent the rivets from squeezing out between the parts of the joint. A convenient means of locating and holding metal sheets to each other and to adjoining structural members is fasteners known as "Cleco Sheet Holders." These consist simply of a small steel cylinder with a spring-actuated locking plunger. The device is exceedingly effective.

The length of a rivet required for forming a head depends upon the grip or total thickness of metal through which the rivet is driven.

The point of a rivet after driving should be 1½ times the diameter.

3.9. Inspection of Rivets. In inspecting rivets on work submitted, check to see that the rivet shanks fill the holes in the metal (see Fig. 5). If they do not, the following items should be checked:

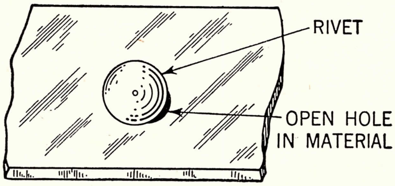
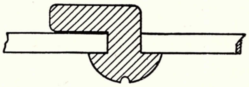


Fig. 5.

1. Correct diameter of rivets.
2. Oversized or elongated holes.
3. Poor alignment of holes in metal to be joined.
4. Rivets too short.
5. Offside alignment of rivets.
6. Insufficient driving of rivets (unfinished operation).

The inspector should consider with caution the conditions enumerated and when in doubt should consult his immediate superior. In primary structures, any one of these conditions warrants close inspection and proper correction. The safety of an installed rivet is as important as any other part of an airplane, a fact not to be overlooked.



CLINCHER RIVET

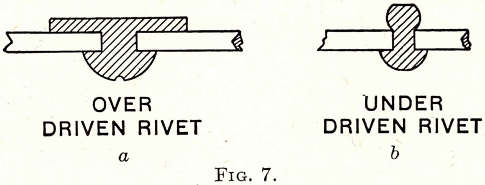
Fig. 6.

A clincher rivet (Fig. 6) is a rivet that has the "bucked" point offside. Clincher rivets are considered not standard and are replaced.

3.10. Unsatisfactory Installation of Rivets. This may be of two kinds, comprising underdriven and overdriven rivets.

1. If an underdriven rivet (Fig. 7*b*) is of the A17S type (not heat-treated), it is permissible to drive the rivet down to the accepted diameter of correctly driven rivets.

2. An overdriven rivet (Fig. 7*a*) is considered poorly installed and should be replaced. However, there are specific cases where rivets are overdriven to within a reasonable depth because clearance is necessary between the points of the driven rivets and a subsequent installation. Specific cases will be called for on the blueprint, and inspectors should become familiar with any definite rivet requirements in order to pass such rivets during inspection.

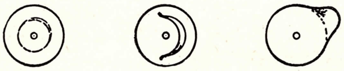


a *b*

Fig. 7.

When rivets of the incorrect type and size have been used, these are replaced for obvious reasons.

3.11. Damage on Installed Rivets. Typical damaged rivets are shown in Fig. 8*a*, *b*, and *c*. All such rivets should be replaced.



a *b* *c*

Fig. 8.

3.12. Rivets Countersunk Incorrectly. Rivets may be countersunk too little or too deep.

When rivets are countersunk too little, they are removed, the depth of the countersink is increased to the correct diameter, and a new rivet is driven.

When rivets are countersunk too deep, it is important that a thorough diagnosis be made. Before making any definite decision, the type of correction should be decided upon.

The importance of correctly installed rivets should be realized. Inspectors should use good judgment during inspection of rivet assemblies.

CHAPTER IV

STANDARDS OF WORKMANSHIP FOR BOLTED ASSEMBLIES

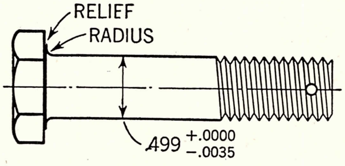
4.1. Introduction. On aircraft bolted assemblies, material of the correct type and length, its proper location, and exact workmanship are important. A discussion of method of identification and coding of aircraft bolts follows.

When ordering bolts, machine screws, clevis bolts, and clevis pins, note that the code symbols for lengths are not interchangeable. For example,

Aircraft bolt -24 = 2½ in. long
Machine screw -24 = $\frac{24}{16}$ or 1½ in. long
Clevis bolt -24 = $\frac{24}{16}$ or 1½ in. long

Clevis-pin dash numbers are odd. *Example:* -25 = $\frac{25}{32}$ in. long.

4.2. Identification and Coding of Aircraft Bolts. Aircraft bolts are coded for length by inches and eighths. For all lengths below 1 in. the single figure means eighths; *i.e.*, -6 means ⅝, or ¾ in. The figure "1" followed by zero, *i.e.*, "10", means 1 in. long. A 1⅛ in. long bolt is designated by "11"; a bolt 1¼ in. long, by "12"; and so on, up to 1⅞ in. For a bolt 2 in. long, write "20."



HEX. HD. BOLT
FIG. 9.

AN bolts are hex-head bolts (see Fig. 9).

AN 3 DD -4 = Aluminum Alloy Aircraft Bolt $\frac{3}{16}$ in. dia. × ½ in. long
└Lengths in eighths.
└Aluminum alloy bolt (see example below).
└Diameter in sixteenths.
└Army and Navy standard part.

Example of part number: AN3-4 = bolt — steel
AN3DD-4 = bolt — aluminum alloy

Add "A" to the part number for a bolt without a cotter-pin hole. *Example:* AN3-4A.

The head of an aircraft bolt has an "X" on the head if the bolt is heat-treated alloy steel of a minimum tensile strength of 125,000 p.s.i.

There is a raised "–" on opposite sides of the top of the head if the bolt is aluminum alloy.

An AN standard steel aircraft bolt is identified by a raised asterisk on the head. An AN standard bolt on which any rework has been done such as shortening of the bolt to eliminate the cotter hole, drilling of the cotter hole, drilling of the head, or thread-relief undercutting should have a circle inscribed around the asterisk.

The head of a nickel steel bolt other than an AN standard with a minimum tensile strength of 125,000 p.s.i. has an "X" stamped on the head.

All fully special bolts (dimensionally nonstandard, special material, high heat-treatment, etc.) bear, stamped on the heads, either the part number or the abbreviation "Spec."

Unplated bearing bolts have the letter "B" stamped on the heads.

Bolts tested for hardness bear a circular "X" on the heads. Bolts that have received magnetic inspection bear "MF" or "M" on the heads.

It is of great importance to use the correct type of bolt. To ensure this, the blueprint is used to obtain information on the bolts required for assembly or installation.

4.3. The Fit of Bolts. Bolts may be of three different classes with respect to fit, loose fit, tight fit, and press fit.

It will not be difficult to install a bolt that has a loose fit. This does not mean that any size will do. The blueprint is the authority and must be followed conscientiously.

4.4. Tight-fitting Bolts. A tight-fitting bolt is a bolt that requires reasonable force to pass through the hole or holes of parts to be bolted together. Caution is suggested on installations of this kind, for carelessness will result in an unsatisfactory condition, with the danger of possible failure.

4.5. Press-fitting Bolts. Press-fitting bolts are installed with machine presses. The blueprint usually specifies reamed holes for press-fitting bolt assemblies. A press fit suggests that great loads are expected to bear on the bolt; therefore, play between bolt and material is to be avoided.

The material for clevis bolts and their use are established by the engineering data on the blueprints. Since their use does not coincide with that of the regular aircraft bolts but is mainly for shear loads, it is necessary that their uses on installations be definitely checked by consulting the blueprint.

4.6. Taper Pins. Taper pins are frequently used in aircraft. Inspectors are interested in the coding of taper pins when inspecting taper-pin installations.

4.7. Identification and Coding of Taper Pins. An example of the decoding of a taper pin is as follows: AC386 threaded taper pin. This may be decoded thus: AC386-1-8, which indicates a No. 1 taper 1 in. long (see Fig. 10).

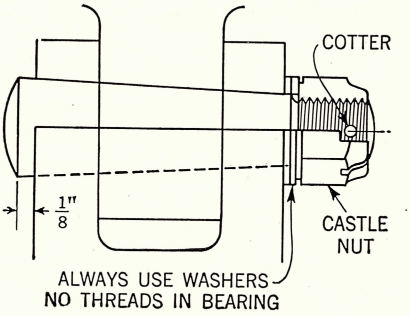


FIG. 10.

4.8. Reaming for Taper Pins. It is important that the reaming operation is not carried to the extreme. The amount of reaming can be judged by the length of the taper pin extending its threaded end through the material in which the taper pin is installed. The result is that the threads are completely exposed and the taper-pin shank does not protrude excessively.

The head of a taper pin installed should not be driven in too much (it should not be even with the surface of the adjacent material). If it is driven in too far, it should be submitted to an engineer for his opinion as to the safety of the installation. The correct installation of a taper pin is important in regard to the proper contact between the shank of the taper pin and the adjacent material.

4.9. Installation of Taper Pins. Taper pins may be installed with

1. Stop nuts (no other locking device used).
2. Shear nuts (used with cotter pin).

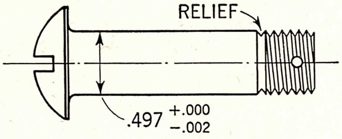
3. Aircraft castle nuts (used with cotter pin).
4. Flat nuts (special lock washer).

Special taper-pin spacing washers are used frequently.

Special locking washers are used with plain nuts.

Taper-pin installations are inspected and checked for type, length, and material by reference to the blueprint and the standard parts book.

4.10. Use of Clevis Bolts. Clevis bolts (Fig. 11) are used in place of clevis pins when it is desired to have the greater security afforded by a threaded castle nut and cotter pin than by a cotter pin alone.



CLEVIS BOLT
FIG. 11.

Clevis bolts and pins are designed principally for shear loading. They are made of the same material as aircraft bolts and have an "X" on the head, indicating that they meet AN specifications.

4.11. Coding of Clevis Bolts. The AN numbers from 23 to 36 inclusive designate the diameter of clevis bolts in sixteenths, the last digit giving the diameter in sixteenths. For example,

AN23 = $\frac{3}{16}$ in. dia.
AN29 = $\frac{9}{16}$ in. dia.
AN30 = $\frac{10}{16}$ or $\frac{5}{8}$ in. dia.

Above 30 the designation is as follows:

AN32 = $\frac{3}{4}$ in.
AN34 = $\frac{7}{8}$ in.
AN36 = 1 in.

The length of clevis bolts is coded in sixteenths.

Add "A" after the dash number for a bolt without a cotter-pin hole. For example,

AN23-8 = $\frac{3}{16}$ in. dia. × $\frac{1}{2}$ in. long drilled for cotter pin
AN23-8A = $\frac{3}{16}$ in. dia. × $\frac{1}{2}$ in. long undrilled
AN 23 -8 A = $\frac{3}{16}$ in. dia. × $\frac{1}{2}$ in. long undrilled clevis bolt
A —Undrilled.
-8 —Length in sixteenths.
23 —Diameter in sixteenths (see above).
AN —Army and Navy standard part.

Bolt Codes:
AN3 to AN16 incl; reserved for hex. headed bolts
AN23 " AN36 " " " clevis bolts
AN42 " AN49 " " " eye bolts
AW13 " AW81 " " " drilled hex. headed bolts.

4.12. Coding of Flathead (Clevis) Pins. The AN numbers from 392 to 406 inclusive designate the diameter of clevis pins in sixteenths, the last digit giving the diameter in sixteenths. For example, in the following the "2" is interpreted thus:

AN392 = 2⁄16 or 1⁄8 in. dia.
AN400 = 10⁄16 or 5⁄8 in. dia.
AN402 = 12⁄16 or 3⁄4 in. dia.
AN406 = 16⁄16 or 1 in. dia.

In ordering, clevis pins are coded for grip length only. The grip is given in thirty-seconds, and dash numbers are odd, thus: -7, -9, -11, etc.

AN 392 -7 = Flat-head Pin 1⁄8 in. dia. × 7⁄32 in. long
-7 — Grip length in thirty-seconds.
392 — Diameter in sixteenths (see example above).
AN — Army and Navy standard part.

4.13. Correct Bolt Installation. In inspecting a bolted assembly, it is important that the nut and washer occupy all the threaded length of the bolt.

4.14. Blueprint Information Used for Bolt Installation. The manner of installation, type and material, and length and size of bolts, washers, and nuts and the means of safety for an installation are of great interest to the inspector. Familiarity with the requirements of the blueprint involved and familiarity with standards of workmanship constitute the essentials of correct inspection.

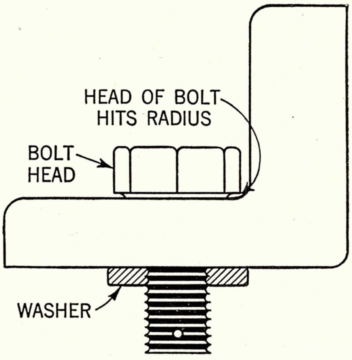


Fig. 12.

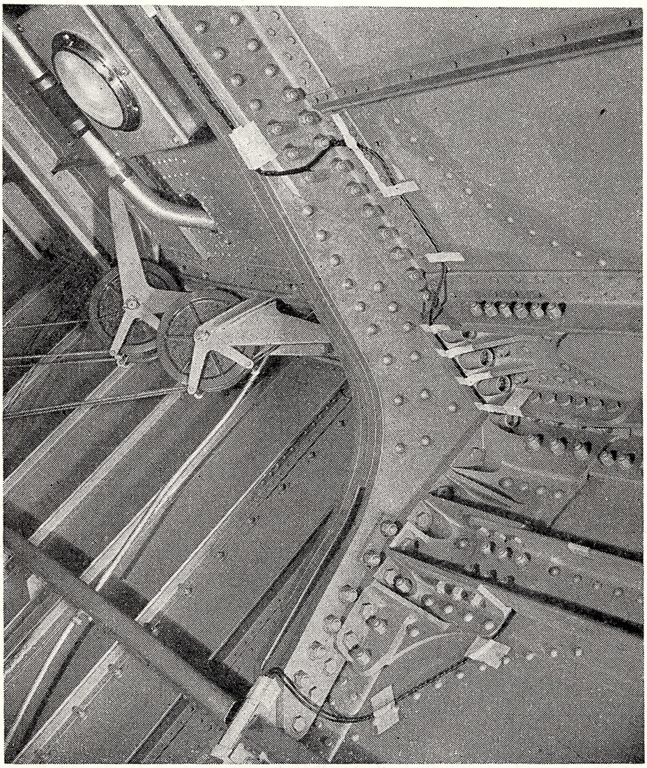
4.15. Inspection of Bolted Installations. There are enumerated below certain requirements and conditions in bolt installation that are of interest to the aircraft inspector.

1. The bolt, washer, nut, and means of safety must be as called for on the blueprint.
2. The holes through which bolts are passing must be of correct size. It should be determined whether they are drilled or reamed.

Clevis pins
AN numbers 392 to 406

3. Tolerances affecting the fit of the bolt in the hole must be checked.

4. The alignment of the holes must be checked. Holes should not be forced into alignment; if the alignment is unsatisfactory, the opinion of an authorized person should be obtained.



Typical bolt installations in an aircraft structure. (*Courtesy of Douglas Aircraft.*)

5. No substitution is permitted. However, under certain circumstances, deviation from blueprint requirements may be granted by the engineering department transmitting such information through proper and authorized channels.

6. The correct length of a bolt is important; on having been installed, it should have not more than one thread inside any material through which the bolt passes. Bolts of sufficient length are called for on the blueprints, permitting the use of a

washer under the nut. A washer under a nut is desirable for two reasons: (1) It prevents cutting of the material during the turning of the nut. (2) It gives the added assurance that the nut has not run out of thread travel, although it appears to be tight.

7. It is required that the base of the head of a bolt as well as the surface of a washer and nut rest on a level surface over their entire base (see Fig. 12).

8. It is considered unsatisfactory if a bolt and its nut are installed at an angular setting, such as riding in a radius, etc. (see Fig. 13).

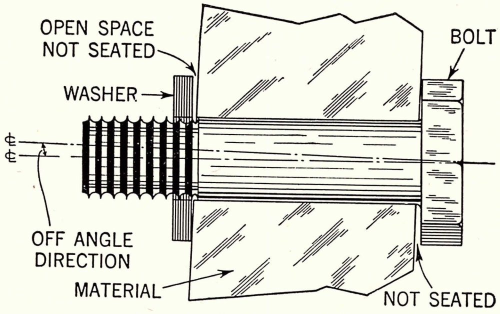


Fig. 13.

9. Sufficient edge distance of bolts on castings, fittings, etc., is important; if found questionable, the opinion of an authority should be consulted.

10. Blueprint requirements regarding means of safety of bolt installation are definite. Thorough knowledge of such requirements is essential.

11. Requirements are given in finish specifications regarding lubricants affecting bolts and their installations. It is one of the duties of an aircraft inspector to familiarize himself with these requirements.

12. Special notes may be found on blueprints, calling for a specific installation of a bolt in regard to direction in which it is to be installed, the type of nut used, and the means of safetying.

13. Compliance with accepted aircraft standards of cotter-pin installation is essential.

Attention to the foregoing is conducive to correct and reliable inspection of bolted aircraft assemblies and installations.

Lock Washers

1. Internal teeth

CHAPTER V

STANDARDS OF WORKMANSHIP FOR AIRCRAFT WASHERS

5.1. Introduction. Aircraft washers serve a number of purposes, which determine their material, type, size, etc. Inspectors should consult the blueprints for information on how the washers are to be used.

5.2. Identification of Aircraft Washers. There are flat washers, lock washers, serrated washers, star washers, and washers for contoured surfaces.

AN935 lock washer. AN935 is a plain medium lock washer. The numeral after the dash indicates the size of the standard bolt for which the washer is suited. For example, AN935-10 is a washer for a No. 10 bolt.

AN936 lock washer; external or internal or with countersunk teeth. This washer is available in steel and bronze. The letter "B" after the numerals is used to indicate bronze. No letter is used for steel. Code letters are provided to identify the type of the teeth of the washer and these code letters are located after the "dash," *e.g.*, AN936-A416 indicates a washer having internal teeth, for a ¼-in. bolt, steel. AN936-B416 indicates a washer having external teeth, steel. AN936-C416 indicates a washer having countersunk teeth. The following will illustrate the manner in which the material is specified, *e.g.*, AN936-A416B indicates a washer having internal teeth and is made of bronze.

AC945 plain commercial standard washer. AC945 is a plain washer. When ordering, give part number, name, and size of bolt. This washer may be decoded as follows: AC945-8 indicates a washer for an 8⁄16-in. bolt, the number after the dash being in sixteenths of an inch.

AN960 plain washer. This washer is made of steel unless "A" for aluminum, "B" for brass, "C" for corrosion-resistant steel, or "D" for aluminum alloy is inserted in place of the dash. The numeral after the dash or letter indicates the standard bolt size for which the washer is made. For example, AN960B10 is a plain brass washer for a No. 10 bolt.

5.3. Flat Washers. Flat washers are used to space correctly the installation of a nut in its relation to the threads of a bolt, to prevent cutting into structural material during the tightening of the nut, to increase the surface contact, and to support the base of a bolthead or nut on the material being bolted together. It should be remembered that any spacing by washers should not change the accepted principle that not more than one thread of the bolt be inside of material to be assembled (see Fig. 14).

In some special cases, aluminum alloy bolts may be called for on the blueprint. If so, dural washers are used with these bolts.

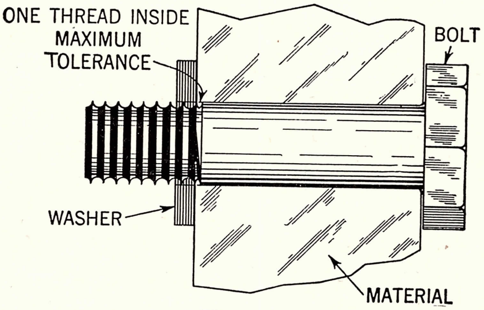


Fig. 14.

Bolts of this material may be found near magnetic-compass installations. Brass washers are usually found on instrument installations in combination with brass screws or bolts. Aluminum washers are used on electrical installations.

5.4. Lock Washers. Lockwashers are used where cotterpins or safety wire is not called for on the blueprint. They are not used under elastic stop nuts, for they are self-locking. A lockwasher upon removal of the tension will dig in and scrape a surface during its "backing off." For this reason, as a precautionary measure a flat washer of the same material is used. The action of a lockwasher in creating a lock is based on its inherent spring pressure resisting the tension imposed. The same effective lock exists between a flat washer and its lockwasher. The blueprint is the authority as to the material, type, size, and location of lockwashers.

5.5. Serrated and Star Washers. Serrated and star spring washers not only are used for locking purposes but in addition serve the purpose of "bonding." The use of such washers is established either by blueprint or by other authorized information.

5.6. Special Contour Washers. Washers used as locking devices for contoured surfaces in special cases are shown in Fig. 15.

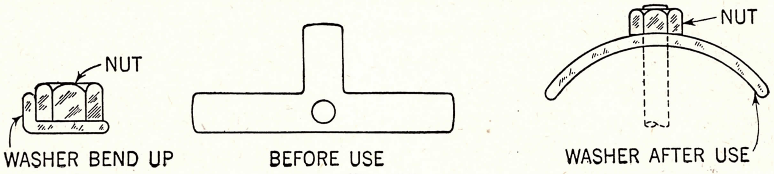


Fig. 15.

5.7. Inspection of Installed Aircraft Washers. The following is a summary of items to note during inspection of washer installations:

1. The material, type, diameter, and location of the washer and its use should be as called for on the blueprint.

2. The maximum tolerance of washers for spacing purposes must not be exceeded.

3. The spacing by addition of the washer under the head of the bolt should not change the number of threads (one is the maximum) inside of material being joined.

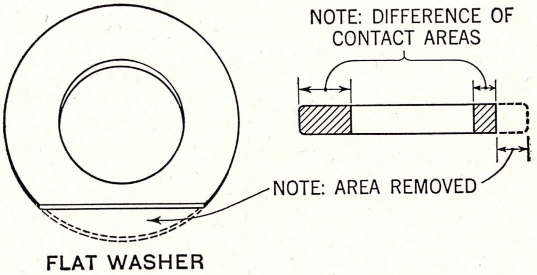


Fig. 16.

4. Bolt, lock washer, and flat washer should be of the same material.

5. The flat washer should be correctly seated on the underlying surface (note the outside-diameter clearance of the washer).

6. The type of washer used for bonding purposes should agree with that specified by the blueprint or other authorized information.

7. Washers for contoured surface or special washers should be installed correctly.

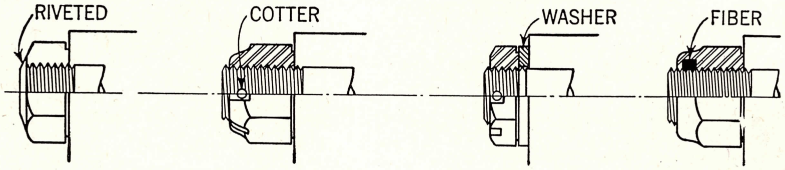
8. No material should be removed from any washer in order to accommodate installation (see Fig. 16).

A washer is used for a definite reason and purpose. Its correct and neat installation is one of the many details showing good workmanship and inspection.

CHAPTER VI

STANDARDS OF WORKMANSHIP FOR AIRCRAFT NUTS AND NUTPLATES

6.1. Introduction. Exact standards of workmanship must be applied in the production of the nuts and nutplates used in aircraft. In addition, their proper and correct uses are important. Since the parts described in this chapter are designed and made for certain purposes, it is essential that upon inspection of any work the necessary information on the purpose for which the work is designed be obtained by consulting the blueprint.



PLAIN NUT AN - 315 | CASTLE NUT AN - 310 | SHEAR NUT AN - 320 | SELF LOCKING AN - 365

Fig. 17.

6.2. Identification of Aircraft Nuts. The following is a list of the nuts most commonly used in aircraft work (see Fig. 17):

AN310 castellated. Range by sixteenths from $\frac{3}{16}$ to 1 in. Steel or aluminum alloy.

AN315 plain. Range by sixteenths from $\frac{3}{16}$ to 1 in. Steel or aluminum alloy.

AN316 check. Range by sixteenths from $\frac{3}{16}$ to 1 in. Steel only.

AN 320 shear. Range by sixteenths from $\frac{3}{16}$ to $1\frac{1}{4}$ in. Steel and aluminum alloy.

AN350 wing. Range by sixteenths from $\frac{10}{32}$ to $\frac{1}{2}$ in. Steel or brass.

The above nuts are coded thus:

AN 310 D -4 = Aluminum Alloy $\frac{4}{16}$ in. dia. of tap × 28 threads.
└Diameter in sixteenths.
└Aluminum alloy.
└Type.
└Army and Navy standard part.

AC356 lock nut (Use on engines only)		AC365 self-locking (Do not use on bolts with cotter holes)		
Dash number	Thread number	Steel	Dash number, aluminum alloy	Thread number
1032	10–32	1032	D1032	10–32
428	¼–28	428	D428	¼–28
524	5/16–24	524	D524	5/16–24
624	⅜–24	624	D624	⅜–24
720	7/16–20	720	D720	7/16–20
820	½–20	820	D820	½–20
1018	⅝–18			
1216	¾–16			

AC366 nut plate
AC367 nut plate (countersunk)
Order same as for AC365 above.

The special information on magnetic inspection given with respect to bolts applies to nuts.

6.3. Use of Shear Nuts. It is important that shear nuts should not be used on tension-bolt installations. A nut designed for use on tension bolts has a certain number of threads sufficient to transmit the full tension load without the danger of stripping. On bolts carrying shear loads a shear nut is used which has fewer threads and is not designed to carry tension loads. It is always necessary to inspect each type of nut with respect to how and where it is used.

6.4. Unsatisfactory Conditions. Standards of workmanship may be further emphasized by enumerating here conditions considered unsatisfactory.

1. When a wrench of incorrect fit is used in tightening a nut, it will result in damage to the corners of the nut body. The removal of such a nut is difficult. In addition, the finish protecting the material surface is impaired by the slipping of wrench, and its purpose thus is defeated. A nut having been so damaged should be replaced.

2. Nuts with incorrectly manufactured threads should not be used; for damage will result to the clean threads of the bolt, and an unsatisfactory condition will exist.

3. The number of threads on a nut must match those on the bolt.

4. Cross threading will result in a damaged installation. Such an installation cannot be considered a safe one.

5. Nuts tightened unwisely may be left with stripped threads.

6. Removing part of the nut body to facilitate installation is not acceptable. A nut has a certain contact area on its base, and the designing engineer assumed this area as it is known; therefore, any reduction of this contact area will change the theoretical value, and for this reason the nut should remain in its original state (see Fig. 18).

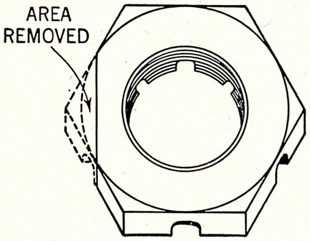


Fig. 18.

6.5. Stop Nuts. The foregoing discussion applies also to elastic stop nuts. The use of elastic stop nuts in the aircraft industry has increased vastly, and the dependability of this type of nut is well established. It therefore is to the interest of personnel in this industry, and particularly to inspection personnel, to be familiar with their design and principle as applied on installation of these nuts.

6.6. Principles of the Stop Nut. The following describes the principle and operation of the stop nut.

1. The elastic stop nut is a standard nut with the height increased to incorporate a fiber collar. This added height corresponds approximately to the thickness of a lock washer.

2. The fiber collar is made from one or more washers of fiber of a special grade. The diameter of these washers is smaller than the diameter of the bolt, and the washers are not threaded. Before the bolt reaches the fiber washer, the elastic stop nut is like a standard nut, with the play between thread flanks the same as on standard commercial nuts. This play, necessary as it may be for easily assembly, is the main reason why an ordinary nut backs off under vibration.

3. When the bolt reaches the fiber collar, progress of the bolt is momentarily retarded by the smaller hole in the collar, and the bolt creates a pressure on it.

4. In so doing, the nut is forced upward until the thread flanks are in contact. The harder the fiber material, the greater

the force necessary to get the bolt to enter and the harder the nut is forced upward. This pressure is distributed on the underside of the bolt threads (this is most important) which is the same side that will later carry the load when the nut is drawn home. This pressure causes considerable friction between the metal threads which further increases when the nut is drawn home.

5. After the upward pressure has reached the maximum, the bolt enters into the fiber collar. The fiber wedges into the bolt threads and the fiber collar closes around the bolt with an air-tight grip.

The elastic stop nut is then locked to the bolt alone and not to any support.

6.7. Locking Materials for Stop Nuts. There are two kinds of "locking" materials used in stop nuts, *viz.:*

1. A special fiber material. When this material is used, the fiber stop nuts are not used in places where they are exposed to high temperatures.

2. A special metallic material. Stop nuts incorporating this material are used where they are exposed to higher temperatures.

6.8. Restrictions Affecting Stop Nuts. Restrictions affecting stop nuts are as follows:

1. Elastic stop nuts are not used with bolts drilled for use with cotter pins (Fig. 19).

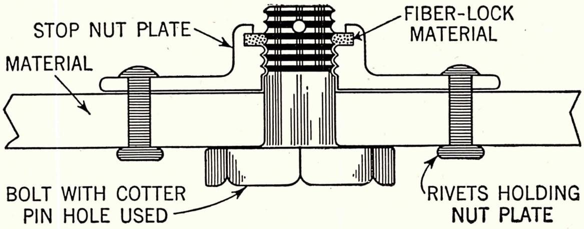


Fig. 19.

2. No lubricant of any kind is used with stop nuts.

3. See the limitations mentioned above with respect to the temperatures to which these nuts may be exposed.

4. Stop nuts are not used at control-system joints involving relative motion between the parts joined.

5. Stop nuts are not used at joints that will tend to loosen them.

6.9. Nut Plates. The standards for other types of aircraft nuts are applicable to nut plates. In addition, they are checked for the following:

1. Unsatisfactory attachment. Rivets used for attachment driven poorly. Misalignment of nutplate.
2. Tapped out to facilitate assembly.
3. Cracked at attaching base (Fig. 21). This condition is generally caused by insufficient edge distance, oversized rivet holes, or excessive or offside pressure during riveting.
4. Filed to fit on installation (Fig. 20).

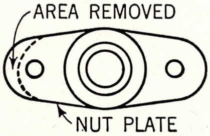


Fig. 20.

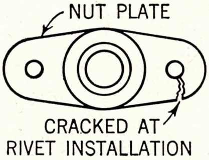


Fig. 21.

5. Incorrect type used.
6. Incorrect size used.
7. Incorrect number of threads per inch.
8. Wrong or no protective finish.
9. Improper contact on attaching surface.
10. Lubricant used on threads.

6.10. Conclusion. In inspecting nut installations, it is essential to be familiar with blueprint information, technical data, and standards of workmanship. A nut installation free from mechanical errors and complying with all other requirements ensures a safe installation and presents a mechanical appearance as desired in aircraft.

CHAPTER VII

STANDARDS OF WORKMANSHIP FOR COTTER PINS AND SAFETY WIRE

7.1. Purpose of Cotter Pins. Cotter pins are used to safety a bolt or clevis-pin installation. Their identification and coding is of interest.

7.2. Identification of Cotter Pins.

Dash Number

Length, in.	Diameter, in.					
	1/16	3/32	⅛	5/32	3/16	¼
½	2-2	3-2	4-2	5-2		
¾	2-3	3-3	4-3	5-3		
1	2-4	3-4	4-4	5-4		
1¼	2-5	3-5	4-5	5-5		
1½	2-6	3-6	4-6	5-6	6-6	
1¾	2-7	3-7	4-7	5-7		
2	2-8	3-8	4-8	5-8	6-8	8-8
2½	...	...	4-10	5-10	6-10	8-10
3	...	...	...	...	6-12	8-12
3½	...	...	...	...	...	8-14
4	...	...	...	...	...	8-16

For smaller diameters than 1/16-in. cotter, use wire 0.041 steel.

Dash numbers listed are for low-carbon steel.

Add "C" before the first dash number for corrosion-resistant steel.

Example of part number: AN380-2-2 = low-carbon steel.
AN380C2-2 = corrosion-resistant steel.

The numeral after the first dash indicates the diameter of the pin in thirty-seconds of an inch, and the numeral after the second dash indicates the length of the pin in fourths of an inch.

7.3. Standards for Cotter-pin Installations. Certain standards for cotterpin installations are required in aircraft. In Fig. 22, it will be noted that the legs, or prongs, of the pin are cut and bent so as to make a correct safety installation and prevent the danger of injury. This cutting is done so that the prong being bent over the end of the bolt will not extend beyond the bolt diameter and the other prong will not rest against the surface of the washer under the nut. The prongs are bent or curved over a reasonable radius, not a sharp radius, as the latter procedure involves a possible danger of breaking. A correctly installed cotter pin can readily be removed whenever necessary and will facilitate service on installations classified as removable or adjustable.

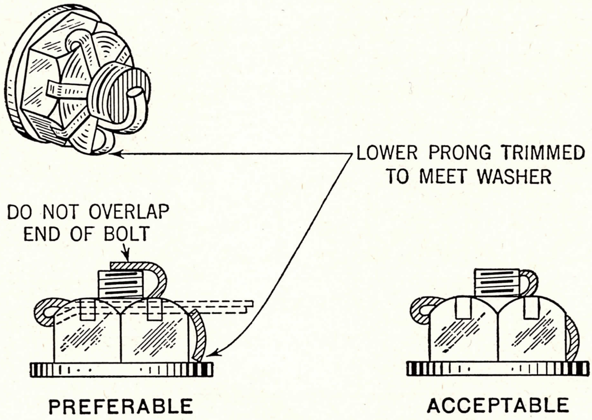

LOWER PRONG TRIMMED TO MEET WASHER
DO NOT OVERLAP END OF BOLT
PREFERABLE
ACCEPTABLE

FIG. 22.

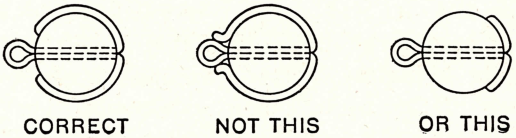


FIG. 23.—Application to clevis pins, guard pins, etc.

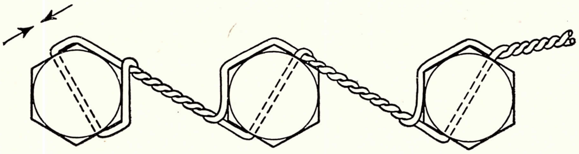
In order properly to cotter a bolt, it is permissible to add a washer of the correct material under the nut.

The accepted standards for cotter-pin installations on clevis pins, guard pins, etc., are as shown in Fig. 23.

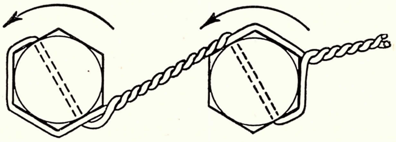
7.4. Unsatisfactory Cotter-pin Installations. A cotter pin having play lengthwise after installation or a distorted head due to having been driven in too tightly is not considered to conform to aircraft standards.

7.5. Use of Safety Wire. Drilled-head aircraft bolts are used where nuts and cotter pins cannot be used. Safety wire is used with such bolts. Safety wire may be of steel, brass or, copper.

7.6. Coding of Safety Wire. *Example:* AC995 lockwire. AC995 is a plated lock wire unless "C" appears after the number 995 in which case the material is copper. The numeral after the first dash indicates the diameter of the wire in thousandths of an inch, and the numeral after the second dash indicates the length of the wire in inches. Therefore, 995C32-10 is a copper lock wire 0.032 in. in diameter and 10 in. long.



CORRECT



INCORRECT

Fig. 24.

It is part of good and dependable inspection definitely to ascertain the material of safety wire and its diameter by referring to the information given on the blueprint.

7.7. Surface of Safety Wire. The surface of safety wire is often protected either by plating or by tinning, depending on its material. The condition of this surface protection is of interest to the inspector. If the plating is improperly applied, it will crack or peel when the safety wire is twisted.

7.8. Installation of Safety Wire. Safety wire is used on nuts and drilled-head bolts to maintain tightness. Certain requirements affecting the installation of safety wire must be met.

1. Safety wire is to be applied so that all pull exerted by the wire tends to "tighten" the nut or bolt.

2. Twists are to be tight and even.

3. The wire is to be between nuts or bolt as taut as is possible without overtwisting.

4. Safety wire should not be nicked, cut, or kinked.

5. Final anchorage is accomplished by twisting the ends (see Fig. 24).

7.9. Correct Selection of Safety Wire. The importance of having safety wire made of the correct material should not be overlooked. Each material serves a specific purpose but is capable of fulfilling this only when used in the correct location. For instance, the safety wire used in the engine section and on instruments, flight controls, and electrical systems is specified on the blueprints with respect to material and size of wire.

CHAPTER VIII

MISCELLANEOUS FASTENERS

There are a number of fasteners used on aircraft, such as Dill Lock-Skru fasteners, Rivnuts, and Dzus fasteners. All these have certain points to be inspected.

8.1. Dill Lock-Skru Fasteners. Inspectors should check Dill Lock-Skru fasteners with the following points in mind:

1. The fasteners should conform to dimensions as shown in the manufacturer's catalogue. It is recommended that these fasteners be rechecked occasionally, particularly if installation difficulties are encountered.
2. The fasteners are furnished with both steel and aluminum alloy heads under different part numbers.
3. Dill Lock-Skru fasteners are furnished with the head and the barrel screwed together, the internal thread in the barrel and the external thread on the head being special threads. They should be checked together to see that they match each other.
4. In cases where the head has an internal thread, the thread should be inspected the same as any nut.
5. The heads that have an internal thread are slotted on the end and pinched together to act as a locking device for the screw that is used with the fastener. This locking device can be inspected by screwing a screw of the required size into the head, a check being made for difficulty in turning as it enters the pinched end.
6. Parts should be checked for burrs which would cause damage to the part being installed or to the material on which it is being installed.

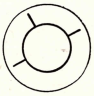
8.2. Rivnuts. Inspectors should check Rivnuts with the following points in mind:

1. Parts are checked dimensionally according to catalogue dimensions.
2. Internal threads should be checked the same as for any nut.

8.3. Requirements for Flush Type Rivnuts. In general, predimpling for Rivnuts is done when the thickness of the material or the sum of more than one thickness does not exceed 0.051 in.

Machine countersinking is resorted to if the total thickness exceeds 0.051 in.

8.4. Identification of Rivnuts. Rivnuts are identified by marks on the head indicating the thickness for which they are suited. The following table gives data on Rivnuts.

Thickness, in.	Identification mark on head	Mark on head
0.051–0.089	Blank	
0.090–0.124	One mark	
0.125–0.154	Two marks	
0.155–0.179	Three marks	
0.180–0.199	Four marks	
0.200–0.219	Five marks	

8.5. Dzus Fasteners. Inspectors should check Dzus fasteners with the following points in mind:

1. Parts are checked dimensionally according to catalogue dimensions.
2. Parts are inspected for burrs under the head which would mar the sheet in which it is installed.
3. The cam slots are checked for burrs.

8.6. Inspection with Reference to Blueprints. It is suggested that inspectors check identification of the various fasteners with reference to the blueprint and by consulting the technical information furnished there regarding size, type, material length, etc. Whenever difficulties are experienced on the assembly or installation, it is best to check such fasteners in addition to all possible causes from other sources.

CHAPTER IX

STANDARDS OF WORKMANSHIP FOR ELECTRICAL AND RADIO INSTALLATIONS

With the extensive present-day use of radio equipment, it has become more and more important that such equipment be unaffected by electrical disturbances of any kind.

9.1. Causes of Radio Disturbances. Radio disturbances may be caused by the sources of alternating or fluctuating voltages and currents, which are as follows: generator, generator-regulator, ignition-system, and direct-current motors. To counteract disturbances caused by this equipment, its circuits are "shielded."

An additional cause of radio-reception disturbances is a vibrational contact of isolated metal parts against the airplane structure or against each other. For example, an unbonded length of tubing is actually an antenna, which can receive energy. This energy is discharged either by "reradiation" or by contact with adjacent structures. In either case a disturbance will result from the discharge of energy.

9.2. Preventing Radio Disturbances. To prevent such disturbances, parts are "bonded." A "bond" is a good electrical connection. Its resistance between two parts is not more than if both parts were one solid unit, and the resistance does not exceed the maximum allowed by the specifications. The maximum resistance permitted the various individual bonds is covered by the process specifications for specific models.

Resistance is determined by ohm readings taken with the milliohmmeter.

9.3. Purpose of Bonding. The purpose of bonding is to

1. Eliminate disturbances in radio reception.
2. Lower the resistance of metal shielding.
3. Eliminate the danger of fire caused by sparks jumping between two metal members that differ in their capacity to carry electricity.

9.4. Joints as Good Electrical Connections. The following types of joint are considered good electrical connections:

1. Welded joints.
2. Soldered joints.
3. Sweated joints.
4. Riveted joints.
5. Threaded wire ends.
6. Screws with lock washers or bonding washers.
7. Bracing.
8. Socket fittings.
9. Pinned fittings wherever driven tight.
10. Clamped fittings that are normally permanent after installation and have a good electrical connection.
11. Pinned fittings that are continuously under heavy tension.

All metal parts that normally are not connected to the structure or do not make good electrical contact should be bonded.

9.5. Bonding Conduits. Methods for bonding conduits of various kinds are as follows:

1. Rigid. Rigid conduit is bonded at certain intervals, which are designated in the process specifications applicable to the model in question. To obtain the proper ohm reading on conduit clamps, it is necessary that the installed clamp make good electrical contact.

2. Flexible. Flexible conduit is bonded by "pigtails." Pigtails are tinned strips of braided copper wire. These bonding pigtails are soldered into the metal covering of the flexible conduit and then wrapped with tape and the tape covered with shellac. Flexible conduit with its bonding provisions already attached are delivered to installation departments. The location of these bonding attachments on flexible conduits is determined by measurements of conduit length in accordance with bonding specifications applicable to the specific airplane model.

3. Tubing. Tubing supported by clamps or blocks that are furnished by the manufacturer with means of bonding built in conform, if correctly installed, to the bonding requirements.

9.6. Bonding Hose Connections. Where tubing is connected by a hose connection, authorized bonding specifications are followed.

9.7. Bonding Large Metal Parts. Large metal parts or assemblies are bonded by pigtails. Under this classification come rudder, ailerons, elevators, doors, instrument boards, radio equipment, etc.

Long metal members, cables, etc., are bonded according to authorized bonding specifications. However, if bonding is called for, great care is necessary to eliminate all danger of fouling during operation.

Detailed and additional information on bonding requirements may be secured by consulting the specifications issued for the model involved.

A good bond usually will have its resistance readings well within tolerances.

9.8. Electrical and Radio Installations. In the modern airplane, electrical and radio installations have become extensive, and certain shop practices have been developed for them.

These installations may be divided into the following groups. Where shop practices and standards of workmanship coincide for any of these groups, special mention will be made of this fact.

9.9. Electrical Equipment.

1. Conduits (rigid and flexible).
2. Junction boxes.
3. Wires.

9.10. Radio Equipment.

1. Supports and installations.
2. Remote-control arrangements.
3. Wires.

9.11. Conduits. The discussion of conduits applies to conduits of both the electrical and the radio system. Conduits are used for protection, for shielding, and for providing the means of carrying wire.

9.12. Installing Rigid Conduits. The material of these conduits is comparatively soft, for a large percentage of the metals used for them is composed of aluminum. This fact is of interest with respect to the manner in which they are supported. Rigid conduits are supported by tubing blocks or tubing clamps. Tubing blocks are used to support more than one piece of tubing, and clamps are used to support only one. Little difficulty is experienced in installing the conduit with either of these if a few precautions are practiced (see Fig. 25).

9.13. Conduit Support Blocks. The following points of installation must be observed in order to obtain a satisfactory installation.

1. The tinned copper bonding strip, which is built into the block by the manufacturer, is not to be disturbed by crimping or misplacing from its original alignment along the vertical center line of the block halves. Its edges must lie smoothly along the contoured surface of the conduit. Its top and bottom folded ends must lie against the metal support of the composite block material in order to make good contact. This can readily be accomplished by leaving undisturbed the original installation of this bonding strip.

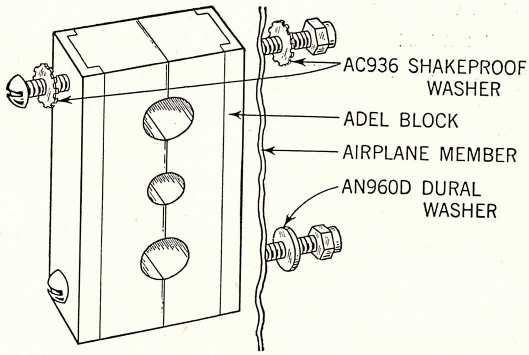


Fig. 25.

2. A conduit passing through a hole of correct diameter in the block should always be at 90 deg., or at right angles, to the sides of the supporting material.

3. Overtightening of a support block is most undesirable, for it endangers the entire unit and its installation. A block should be tightened only until the conduit feels solid in its support when tested by hand.

4. The correct type of bonding washer and its correct location produces a good bond. It is well to remember not to overtighten the installation.

9.14. Conduit Support Clamps. There are two kinds of conduit support clamps available and in use, plain metal clamps and rubber-protected clamps.

The discussion of the preceding section applies to both clamps as far as alignment and tightness are concerned. For L types of clamps without rubber protection, caution is advised in tightening, for overtightening will result often in a damaged conduit. It is permissible to insert a dural washer between the tabs of a clamp in order to prevent damage to a conduit provided that the addition of such a washer does not reduce the normal tightness of the clamp on the conduit (Fig. 26).

The inside surface of the unbonded clamp should be clean and free of oxide film in order to make good bonding contact. It is very important to a safe and good installation to select a clamp of the correct size. A bonding check is used to test the bond of such an installation.

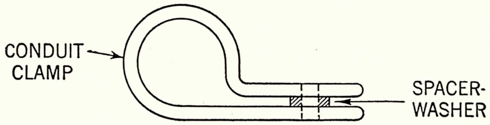


Fig. 26.

9.15. Rigid-conduit Connections. Where two pieces of rigid conduit are joined together by a union, the inspector should keep in mind the following items:

1. The ends of the conduit should be cut straight and should be free from burrs or sharp edges.
2. The inside of the conduit should be clean and dry.
3. The threaded portions of the union should be protected by application of a lubricant as specified in authorized finish and process specifications.
4. The ends of the conduit should enter the union in correct alignment and not at an angle.
5. The ends of the conduit should rest squarely on the shoulder located in the interior of the union.
6. The union should be reasonably tight; if it is overtightened, the conduit will collapse.
7. The correct type of wrenches should be used during the tightening operation to prevent damage to the union and to prevent twisting of the entire union installation.

The points enumerated above produce a correct installation conforming to high aircraft standards.

9.16. Installing Flexible Conduits. Flexible conduits are installed like rigid conduits, with the following additional requirements: The surface of flexible, or shielded, conduit is protected against the surface pressure of a support by tape wrapped around it at the point of support installation. The wrapped tape is covered with an application of shellac and allowed to dry before installation of the conduit support.

9.17. Purpose of Flexible Conduits. The purpose of flexible conduits is to permit movement of the installed conduit. For this reason, the conduit must not be forced over too small a radius, for this will defeat its purpose, *viz.*, flexibility.

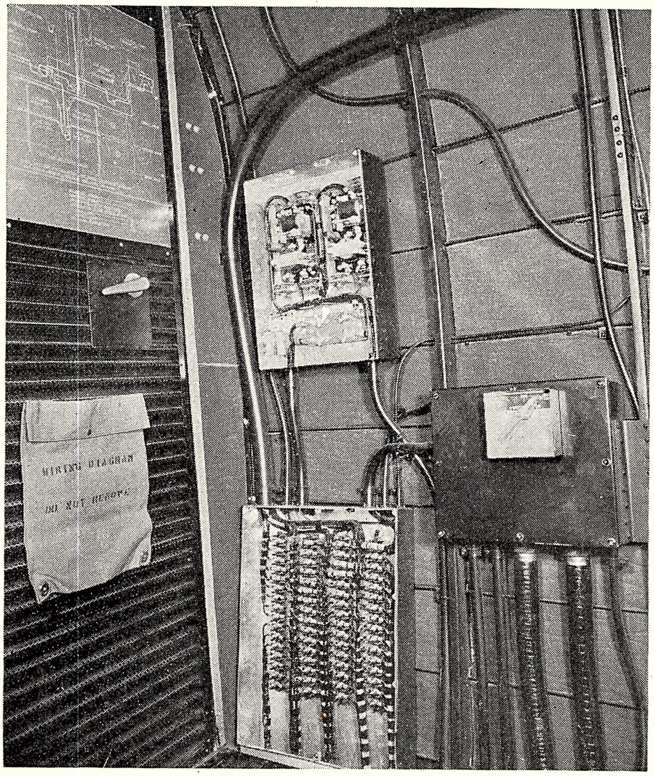
9.18. Bonding Flexible Conduits. Flexible conduits are bonded to adjacent surfaces by means of tinned copper braided strips. A dural washer is used under the head of the bolt or screw in attaching the loose end of these bonding strips, in order to ensure solid contact and to prevent damage to the copper braids during the tightening operation.

9.19. Junction Boxes. Electric junction boxes are used to provide facilities for wire connections and to protect and shield their installation. Inspectors check junction boxes for the following:

1. Shape of junction box not distorted.
2. Junction box not damaged.
3. Interior clean.
4. Provisions for cover attachment not misaligned or damaged.
5. Holes for conduit installation not out-of-round or oversize and free of burrs or sharp edges.
6. No unused holes in junction-box body.
7. Edges on which cover rests smooth and straight (not wavy).
8. Flat washers used in installing box on supporting structure.
9. Box cover not bent or otherwise distorted.
10. Fasteners in cover aligned properly with underlying attachments.
11. Wiring-diagram chart correctly installed on underside of cover and corresponding to installation of wire connections inside box.
12. Chart protected by a coat of clear shellac.
13. Cover in solid contact with edges of junction-box body.
14. Connections of conduit at junction box in alignment and not tightened excessively.
15. Terminal posts on inside of junction box installed according to blueprint and in conformance with specifications applicable to the particular model.

Compliance with the requirements enumerated above produces results conforming to high aircraft standards.

9.20. Electric Wiring. Aircraft standards for electric wiring are exacting and demand skill and knowledge of the methods employed during installation. The following sections will serve as a guide to good practice in electric wiring.



Electrical installations and master switch in a modern airplane. (*Courtesy of Douglas Aircraft.*)

9.21. Identifying Wires. Each wire is identified by a code number, which corresponds to a number shown on the wiring diagram. This number is printed on a label of adhesive tape which is wrapped around the terminal and wire insulation in such a manner that the number is readily seen after the terminal is connected to its terminal post. To protect the number and tape, a coat of white shellac is applied.

There are two different methods of attaching the label with its number.

1. Label is wrapped over friction tape covering shank of lug and insulation. In place of adhesive tape, there may be used a newly developed sleeve of plastic material on which the number is shown.

2. Label is wrapped over cable adjacent to lug.

The specifications issued are the authority on which to base the method to be used.

9.22. Installing Wires. During the process of wire installation, it is important that the following points be observed:

1. The insulation covering wires should not be damaged in any way.

2. All wires are to be separated and untwisted prior to installation. If a wiring assembly is furnished in a coiled condition, the coil should be unwound and wires laid out to facilitate their separation from each other and to correct any twisting of individual wires.

3. Wires in the process of being separated and unwound should not be laid on surfaces that are dirty or covered with metal shavings.

4. Wires are covered generously with powdered soapstone to facilitate installation in conduits.

5. In installing wires in conduits, the ends of the wires are tightened together by cord (*not wire*) and pulled through.

9.23. Special Precautions for Wire Installations.

1. It must be possible to remove and replace an individual wire without the other wires in the same conduit being removed.

2. Tape or cord may be used temporarily to hold together wire assemblies awaiting installation. However, such ties are *not* permitted to enter the inside of a conduit but must be removed when nearing the conduit opening.

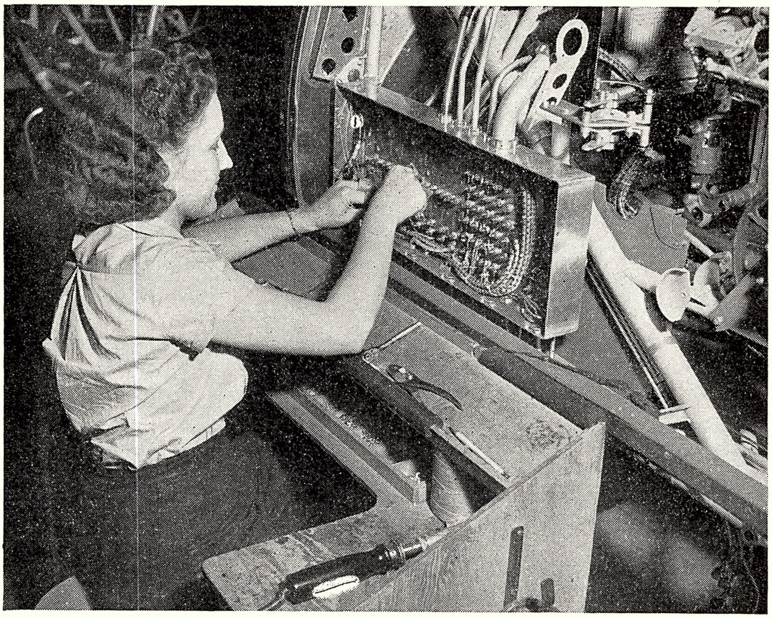
3. Installed wiring at the point of entrance to junction boxes is protected against rubbing by wrappings of friction tape covered by a brush coat of shellac.

4. Wires inside junction boxes should not be forced over acute angles or radii in order to be installed on their respective terminal posts.

5. The terminals themselves should align with their terminal posts and should lie neatly within their allotted space on the terminal-post block.

6. Terminals should be installed in such a way that their identification code number can be seen readily.

7. Lock washers or locking nuts should not be omitted on terminal installations, and excessive tightening of such connections should be avoided.



Electrical-panel-installation wiring operation. (*Courtesy of Vultee Aircraft.*)

8. Identification code numbers are to correspond to the numbers shown on wiring diagrams applying to the particular installation.

9. *No lubrication* of any kind should be applied to any electric wire.

10. *Solderless* connections may be protected by the application of an approved lubricant; the manner of applying the lubricant is prescribed in specifications issued by factory authority.

11. Equipment for holding fuses should be attached securely to their support, and the ends holding the fuses should be in

alignment. The type and size of fuseholders are specified on installation blueprints.

A properly and correctly installed electrical system contributes greatly to the safety of the airplane and its crew.

9.24. Radio Wiring. The foregoing is applicable to both the electrical and the radio system. In addition, radio installations are required to comply with the following:

9.25. Multiple-connection Cannon Plugs. Cannon plugs with their slip joint prongs are to be handled carefully. The numbers shown near each prong on one part must correspond to the ones on the other. The position of each of these halves is to match and coordinate with that of the other.

These connections should not be forced together. One should have entered the other freely and correctly before an attempt is made to tighten the ring screw.

The completed coupling should be tightened only to a reasonable degree. If safety wire is required, it should be installed in conformance with good aircraft standards of workmanship.

9.26. Shock Mounts (Rubber). Shock mounts are used as vibration absorbers on installations of instrument boards, on radio equipment, and on other sensitive instruments.

The inspector should note the following points:

1. The correct type must be used in the proper place. Shock mounts are designed to carry various weights; for instance, the mounts used at the lower end of a pilot's instrument panel are designed to carry a greater load than those used on the upper side of the same panel. Therefore, their correct location is important.

2. Shock mounts should be installed so that the bolt passing through them is vertical in position and does not lean off angle in any direction.

3. Equipment supported by shock mounts is bonded across the rubber insulation by the use of tinned copper braids.

9.27. Remote-control Installations. Radio equipment is frequently located in places inaccessible to the operator during flight. To correct this condition, remote-control arrangements are provided. Their satisfactory operation depends on the following:

1. The remote-control operating shaft must be installed correctly. It is required that the flexible shaft be installed with

the least possible curvature and that all radii be held as large as possible. The clamps holding the flexible shaft should not be tightened to the extent of damaging the shaft housing.

2. The indicators on the dial of the remote-control unit must match those on the corresponding radio set before actual and final hookup is made.

3. The driving end of the flexible shaft should be carefully aligned with its mating part on the radio set before collar and knurled nut are set against it and tightened.

4. It is necessary that during operation of the remote-control arrangement the indications on the dial at either end correspond with each other.

Familiarity with process and finish specifications as issued by factory authority is essential.

CHAPTER X

ALUMINUM THREADED PARTS

10.1. Special Requirements for Aluminum Threaded Parts. The assembly of threaded aluminum alloy parts demands extreme care. Any careless practice will seriously affect the service life and security of installations, possibly with grave danger to equipment and personnel.

Practices that lead to permanent damage and loss of parts should be avoided. At times, valves and similar parts are damaged beyond repair, owing to inexperienced or careless handling.

10.2. Seizures. Lubrication Treatment. Most damage on aluminum threaded parts is caused by mechanical abuse, such as excessive wrench pressure in make-up of joints, distortion of parts by vises, and similar occurences. But a characteristic of aluminum threaded parts is the tendency to "seize," or "gall," when two threaded parts are screwed together.

Thread lubricants are used in the prevention of seizures. The following gives an idea of their various applications:

1. Aluminum, aluminum alloy, brass, and bronze threads subject to adjustment or removal (special lubricant).
2. Steel threads used in bronze turnbuckles.
3. Threads on brass, bronze, and steel fittings.
4. Aluminum and aluminum alloy threads on electrical-system parts.
5. Threads in dural, brass, and bronze fittings in fuel and oil lines (special lubricant).

In addition there are other types of lubricant used for specific purposes, which are identified in process specifications issued by factory authority.

10.3. Seizures. Anodic Treatment. Another means of minimizing the possibility of seizures is the anodic treatment. A very effective and successful method has been developed for taper and straight male threads, which gives maximum efficiency in conjunction with any antiseizure lubricant. This method is known as the "Parkerizing" process. Threads having received the Parkerizing process treatment are easily detected by their copper color. The copperized threads will resist successfully any tendency to seize, or gall.

All these precautions are taken to reduce as much as possible damage to threads and consequently unsatisfactory connections.

10.4. Pipe Connections. The following gives the accepted procedure in making up pipe connections:

1. Clean off all foreign matter.
2. Spread a small amount of specified antiseizure compound on male threads only.
3. Be sure to cover fully the "lead threads," taking care not to permit any compound to enter the opening of the tubing.
4. Put a very slight amount of lubricant between the sleeve and flare of the tubing. Do not let any lubricant enter the opening of the tubing.
5. Before assembling the joint, check to see that the tube is in proper alignment with the fitting and that it does not have to be sprung into position.
6. Thread parts together by hand as far as possible; then loosen the nut a part turn, and jiggle the tube to be sure the flare is down on the seat.
7. Using smooth-jaw wrenches, one on the nut and one on the fitting, draw the joint tight.
8. Avoid excessive wrench pressure when pulling down aluminum alloy tubing.
9. If nuts are pulled down too tight in soft tubing, the flare will be squeezed thin or possibly pinched off. Experience has shown that this is usually the cause of failure in thin-wall soft-tubing installations.
10. *No lubricant should enter the tubing system.*

Knowledge of and practice in the points enumerated are important. Inspectors familiar with these requirements can do much to further acceptable installations by willingly assisting those in need of advice and help.

CHAPTER XI

TUBING

11.1. Selection of Tubing Material. Weight is of major importance in aircraft, and wherever possible aluminum alloy tubing and fittings are used. For the majority of piping installations, aluminum alloy tubing and fittings will meet required service conditions. Usually, the material of fittings and valves should be similar to that of the tube; for example, brass or

Aircraft tubing in stockroom. Note protective covers on ends of tubing. Open ends visible are on electric conduits. (*Courtesy of Douglas Aircraft.*)

bronze fittings should be used with copper tubes, steel fittings with steel tubes, etc.

Much attention is paid to the selection of material to be used in piping installations. The choice is based on the following factors: corrosion, pressure, weight, strength, temperatures, and mechanical strain or service abuse. To guard against corrosion, parts are either plated or anodic-treated, depending on the kind of material being used.

11.2. Tubing for Steam Systems. Aluminum alloy is not recommended for steam service. Copper tube and brass fittings are suitable for low-temperature steam; but, for temperatures higher than 500°F., steel or other high-strength materials should be used.

11.3. Tubing for Several High-pressure Systems. For general high-pressure installations, steel tubes and fittings are used. The higher tensile strength of steel permits a tube of thinner wall and a lighter weight fitting without reducing the ultimate strength of the installation.

11.4. Conditions Affecting Tubing Installations. Mechanical strain and service abuse, as well as bursting pressures, affect tubing installations. Mechanical strains are those imposed by external sources that tend to stretch, bend, shorten, or twist the tube and are caused by vibration, or relative motion of connected parts.

"Service abuse" refers to rough handling of parts by workmen as well as to the wear and tear normally expected to occur in service.

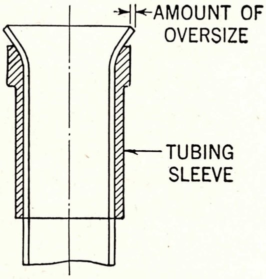
11.5. Safety of Tubing Connections. The safety of tubing connections depends to a great extent on the flares of the tubing. To ensure proper seating, all flares should conform to accepted general requirements and also to certain specific requirements as determined by the type of fitting to be used for coupling the tube. These requirements are correct diameter, angle, squareness, concentricity, radius, and surface conditions.

11.6. Checking Flares on Tubing. For quickly checking flare diameter, gages with holes for measuring "Go" and "No Go" flare sizes are used. Three types of flares are found upon inspection, as follows:

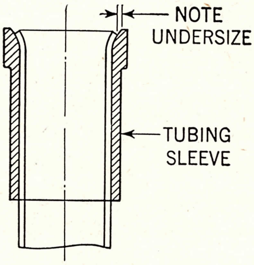
1. Oversize flare (Fig. 27). Tubing flared oversize or too long will stick and jam on the threads in assembling and are

likely to seat against the bottom of the coupling rather than on the tapered seat. Strong wrench pressure cannot be depended upon to bring such flares to a tight seat.

2. Undersize flare (Fig. 28). On tubing flared undersize or too short, the full clamping area of the fitting is not utilized, and owing to the small area of the tube that is clamped the flare may be squeezed thin. Such joints do not offer maximum security against leakage, breakage at the flare, or pull-out strains.



OVERSIZE FLARE
FIG. 27.

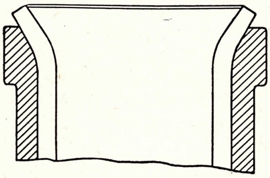


UNDERSIZE FLARE
FIG. 28.

3. Correct flare. A correct flare is shown in Fig. 29.

The result of the use of tubing with correctly flared ends is self-explanatory.

11.7. Flare Angle. The flare angle of the tube should be the same as the flare angle of the fitting. Incomplete flares cannot be depended upon to draw down properly on the fitting seats. In such cases the nut tends to creep up on the flare so that there is very little grip on the tube after the fitting is assembled. For best results, all flares should be completed to the proper angle.



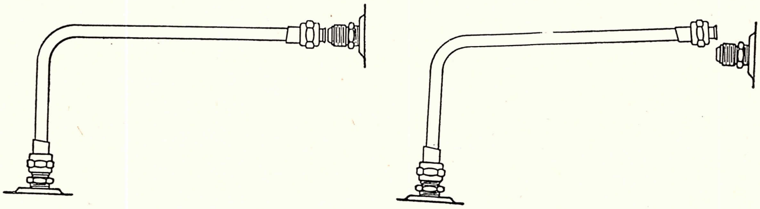
CORRECT FLARE
FIG. 29.

11.8. Unsatisfactory Tubing Flares. Flares must be square and concentric with the tube and tube sleeve in order to seat properly. Flares may be out of square and eccentric because the tube has not been cut off square or because the flare has been unevenly formed in the flaring tool. If the defective form is due to careless use of the flaring tool, then usually the angle of flare is also faulty. Uneven flares are usually not aligned with the fitting seats and require greater wrench pressure to draw tight. If the flare is large, the elongated side will bottom in the fitting to prevent normal seating, or it will stick in the fitting threads. If the flare is relatively small, the shorter side will not be gripped securely between the fitting seats and leakage may develop.

11.9. Inspecting Completed Flares. After a flare has been made, it should be given the same inspection for surface markings as before flaring. If chips, filings, or burrs have not been removed before flaring, they will be embedded in the flare and will cause pockmarks. Pockmarks, scratches, draw marks, or other surface irregularities make tight sealing uncertain and should be guarded against as much as possible. If such marks are present, the flare should be cut off and the tube reflared.

11.10. Split Flares. *Split flares* may be caused by the tube being too hard or of uneven texture or by opening up of scratches or draw marks.

11.11. Bending of Tubing. Tubes should be bent accurately to the correct radius (Fig. 30). A tube that springs out of position when the fitting is disconnected has not been accurately fabricated and is under an initial mechanical stress. For easy assembly and greater assurance against failure of the tube, the tube should be in initial alignment with the fitting.



Tube bent to correct angle so as to be in correct alignment with fitting.

Incorrect bend. Tube is not in initial alignment with fitting.

FIG. 30.

Flattening of the tube at the bend can be prevented by using the correct equipment. In ordinary cases, bending machines produce true round bends when used according to instructions. Tubes of thin wall are the most difficult to bend without flattening but may readily be handled on the production benders, which are equipped with mandrels for this purpose.

Correct bends (Fig. 31) with little or no flattening are produced when correct equipment and methods are employed and proper consideration is given to the corelationship of the radius of the bend, the material, the wall thickness, and the hardness of tube.

Imperfect bends (Fig. 32) may be classified as follows:

1. Flattened. Caused by having the mandrel not far enough forward in the tube, by bending thin-wall tubes without a mandrel, or by trying to bend to too short a radius.

2. Kinked or flattened bend. Caused by slipping of the tube in the bender. Tubes must be firmly clamped in the bend to prevent slippage during the bending process.

3. Wrinkled bend. Sometimes produced when thin-wall tubing is bent without a supporting mandrel.

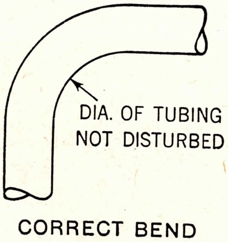


Fig. 31.

11.12. Inspecting Aircraft Tubing. When tubing is submitted, inspectors inspect and check it for the following:

1. Kind of material as called for on blueprint.
2. Condition of material, scratched, nicked, or dented.
3. Length, if not contoured.
4. Coordination with tooling, if contoured.
5. Correct diameter of tubing.
6. Roundness of tubing in area of bends.

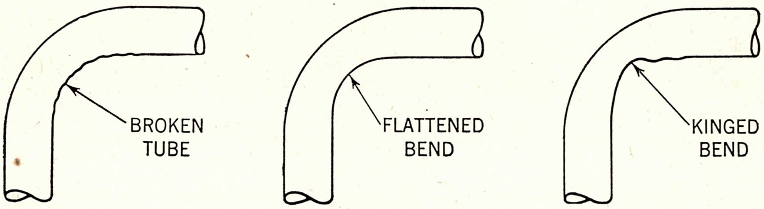


Fig. 32.

7. Correct thickness of tubing wall.
8. Condition of flare, as tube end round, cut square, free of draw marks, mill scale, or scratches.
9. Correct size, oversize, undersize, or offside.
10. Completion of flare to angular requirement.
11. Tubing sleeve according to blueprint.
12. Tubing sleeve free from burrs or sharp edges.
13. Tubing sleeve not too tight on tubing.

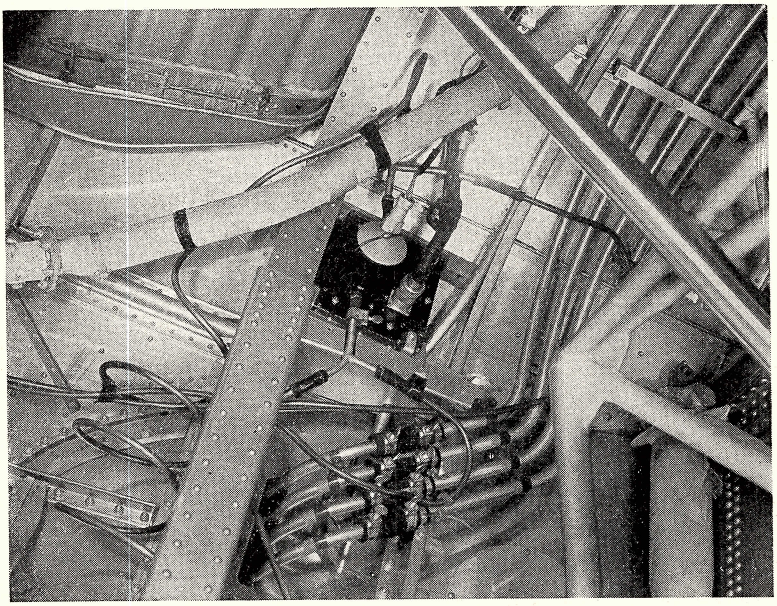
14. Correct material and type of nut, checked to blueprint.

15. Condition of nut and its threads.

16. Tubing, if required, pressure-tested according to authorized factory specifications.

17. Correct color or colors used for identification purposes, as required by factory specifications.

18. Appearance, location, and dimensions of color identification complying with specifications.



Types of aircraft-tubing installations. Note steamlined, looped tubing, hose connections, and tubing-support block. (*Courtesy of Douglas Aircraft.*)

19. Openings of tubing closed in accordance with factory information.

11.13. Conclusion. Tubing systems in the modern airplane are subjected to high operating pressures. To inspect aircraft tubing successfully and efficiently, familiarity with aircraft standards and tubing requirements is essential. The blueprint should always be consulted for all information it contains. Finish specifications and processes applicable to tubing installations are important. When in doubt about acceptance or refusal of tubing, the inspector should consult his superior.

CHAPTER XII

TOOLING

12.1. Introduction. Modern aircraft tooling provides the mechanical means for the construction of aircraft. Its products, specially designed and constructed, facilitate the manufacture of parts and assembly of units. Tooling guarantees uniformity and interchangeability of parts or units and is indispensable to present aircraft manufacture.

Center section of Lockheed Hudson bomber resting in jig. (*Courtesy of Lockheed Aircraft.*)

It is not possible here to go into details of tooling design and manufacture. These constitute a separate field in themselves. Inspectors on production lines are generally not required to inspect tooling; this is carried out by specially trained inspectors.

However, the use of tooling on production floors is of interest to production inspectors, and therefore a brief discussion of tooling follows.

12.2. Importance of Correct Handling. Tooling is expensive to produce, and its correct use and handling are important. Tooling may appear to be just a collection of iron and steel, but upon closer inspection it is discovered that fine and accurate machine operations have been used and extremely close limits and tolerances built into it. But the best designed and built tooling is definitely endangered if it is not used and handled as expected.

Conditions or practices not desirable and points to be observed in the use of production tooling are as follows:

12.3. Misaligning Holes Forced into Alignment. Should a case exist where two parts do not coordinate in their holes, force should not be used to bring such holes into alignment. It should be remembered that doing so will mean only a temporary correction. It can reasonably be assumed that upon removal of the unit from the jig the unit itself will be incorrect or perhaps sprung. When holes between a jig and parts do not readily line up, the cause or reason of the misalignment should be established and corrected before proceeding with the work on hand.

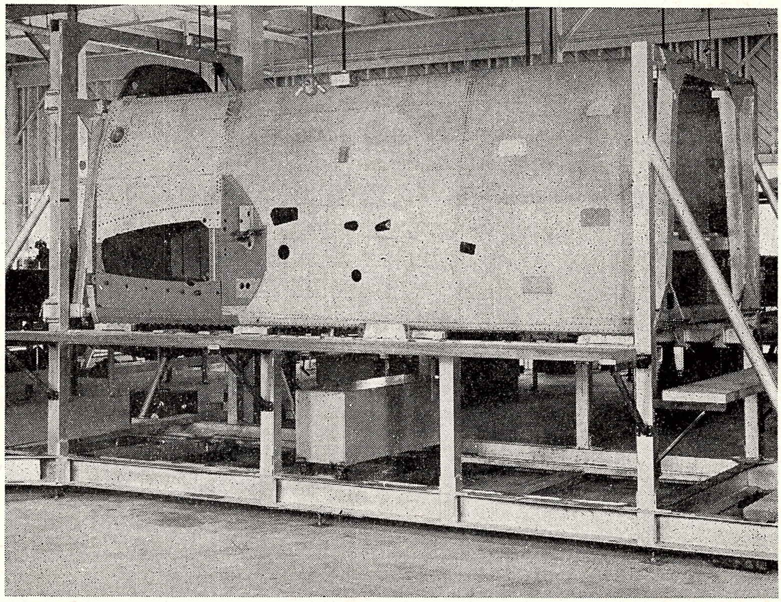
12.4. Misaligning Pins Forced into Position. The word "pin" in the language of tooling means a machined part with close tolerances. A pin is used on a jig or fixture definitely to hold an important dimension, and if it were not considered a most important part of its tooling the expense and time involved in its making would not have been allowed. For these reasons, tooling pins should be treated as finely machined parts. When a pin cannot be installed owing to holes not matching, it should not be forced. Should such a pin be forced into position, the result will be

1. Springing and so preloading the units affected.
2. Enlargement of the holes through which the pin is forced.

Pins generally are case-hardened, and their surface will not give. The resulting damage to the diameter of the holes after a pin has been forced in is self-evident and not consistent with good mechanical standards. It should therefore be avoided by determining the cause of misalignment and correcting any errors.

12.5. Unauthorized Drilling or Reaming. Tooling should not be made to "fit" by drilling or reaming of holes that present difficulties. If the size or direction of a hole on a part of tooling appears to be incorrect, this should be reported to the proper authority.

12.6. Drill Bushings in Poor Condition. Drill bushings are installed in tooling to guarantee the correct diameter of holes to be drilled and to assist in holding the desired direction of drill. These bushings should not be broken or loose in their attachments. Checking of their condition is advised to ensure correctly drilled holes. Any bushings found in questionable condition should be replaced. Any bushings found missing must be installed.



An airplane is made up of thousands of parts, some small and some large. All these parts are built up in jigs. Here is shown one of the larger sections of the airplane, the forward part of the fuselage and the jig in which it is built. (*Courtesy of Northrop Aircraft.*)

12.7. Bolts Used in Place of Tooling Pins. Bolts should never be used in place of tooling pins. The diameter of tooling pins is generally held to a decimal dimension with extremely close limits. Substituting a bolt for a tooling pin endangers the results expected, for the diameter of a bolt is not held so close as that of a tooling pin. The difference in "fit" may permit movement of the article under construction and cause errors that are unnecessary and may prove costly. If a tooling pin is missing, a replacement should be requested.

12.8. Attaching Bolts Loose. Where bolts are furnished with tooling and are used for attachment, it is important that they be sufficiently tight to hold the parts in place. Insufficiently tightened attaching bolts will permit errors to creep into units. Attaching bolts should be checked for proper tightness.

12.9. Spacing Material. Spacing material should not be added to obtain acceptable fit of parts and jig. If parts do not match their jig as required, the reason should be established and corrected.

12.10. Tooling Stops. Tooling stops are provided to facilitate the locating of parts in their correct position. For this reason, parts placed in jigs should rest against the stops provided, to ensure uniformity in the finished product.

12.11. Installation of Parts in Jigs. Parts should not be forced or sprung into the position indicated on the tooling provided. An investigation should determine why parts do not fit, and authorized corrections should be made.

12.12. Smaller Tooling Fixtures. Smaller tooling fixtures may be used independently or in combination with larger tooling. It is important not to drop them for this may render them unfit for further use. Careful handling of these fixtures is necessary to ensure correct alignment, etc. When used as part of or in combination with larger tooling, they should be used when progress of production requires it. Attempts to install them on larger tooling at a later time than scheduled may prove extremely difficult if not impossible. Unreasonable force should not be used to place such fixtures in position.

12.13. All Necessary Parts Accounted For. There are cases where, owing to design and use requirements, tooling consists of a definite number of pieces. It is important that, during use of such tooling, all parts required are accounted for and used. Tooling with parts missing should not be used.

12.14. Machined Surfaces. These surfaces should be given every care. No foreign material such as dirt or shavings should be allowed between machined surfaces. When not in use the surfaces should be protected against corrosion by covering them lightly with an approved corrosion-preventive compound.

12.15. Lubrication. Application of an approved and specified lubricant is required in certain instances. Bushings or holes designed to receive closely fitting machined tooling pins should be lubricated to facilitate installation of such pins and to prevent possible damage to the surfaces of bushings, holes, and pins.

12.16. Identification of Tooling. Attention should be given the identification of tooling jigs and fixtures. Generally a plate is attached to such tooling on which is given detailed information, such as identification of parts or assemblies for which the tooling is designed. On it is also found the tooling inspection stamp with its date of acceptance. In addition, information is given on to what extent engineering changes have been incorporated in the tooling.

The importance of tooling cannot be overestimated. The points enumerated in this chapter are overlooked at times; yet noncompliance with tooling design requirements may prove time-consuming and costly.

CHAPTER XIII

STANDARDS OF WORKMANSHIP FOR METALS

13.1. Introduction. On production, it is necessary to hold all delays due to workmanship to a minimum. Inspectors familiar with accepted standards, particularly those affecting aluminum and its alloys, are a great influence in reducing delays. In many cases, work not up to the required standards of workmanship can be accepted with minor rework if authorized applicable shop practices are used prudently. However, if any doubt exists, an authorized person should always be consulted.

It is practical to divide workmanship on aluminum and its alloys into two classes that have been proved by shop experience to cover the bulk of the work. These two classes are structure and plating.

13.2. Structure.

1. During inspection of joggles the following information should be kept in mind: A joggle in aluminum alloy shapes should not be less in length than three times its depth (see Fig. 33).

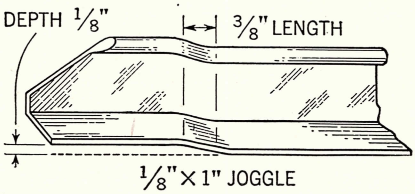
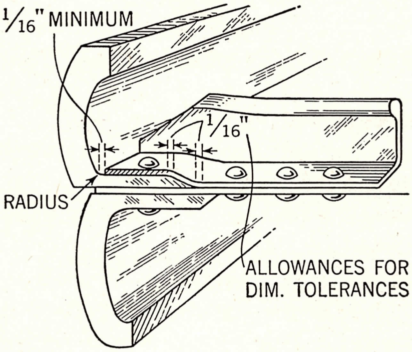


FIG. 33.

Flat sheet may be joggled in a much shorter distance. Joggles are not used with sheet 0.032 in. or less in thickness, except that, when the sheet is in the air flow, it may be joggled for aerodynamical reasons.

2. The end of a joggled bulb angle should have a minimum clearance of $\frac{1}{16}$ in. between its end and the adjoining structure (see Fig. 34).

3. At times, it is found that the end of a joggle is cracked owing to insufficient edge distance or excessive riveting pressure (see Fig. 35). In such a case, it is best to consult an authorized person, especially if the damage is located in a primary structure.



TYPICAL JOGGLE
Fig. 34.

13.3. Cracked Bulb Angle (Longitudinal Stringer). If a longitudinal (bulb angle) in a structure is found cracked, it is necessary to obtain authorized instructions for repair.

13.4. Machine Counterpunching. Machine counterpunching of metals requires close attention by inspection particularly on bulb-angle longitudinal stringers. If the punching operation is carried out incorrectly, the metal forming the cone may have minute cracks. During the riveting operation the pressure of the rivet shank will open these cracks and they can readily be noticed. This condition warrants close attention by inspectors.

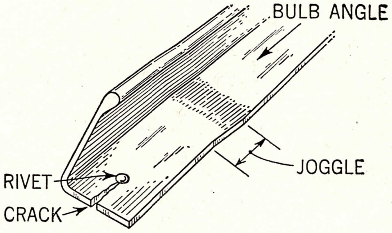
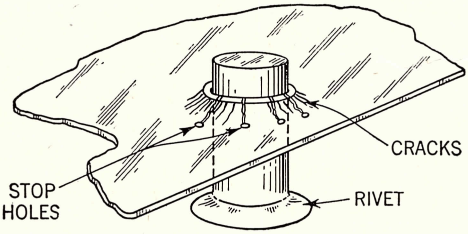


Fig. 35.

If an isolated case exists, it is usually repaired by the shop practice of stopping a crack by drilling a "stop" hole (see Fig. 36).

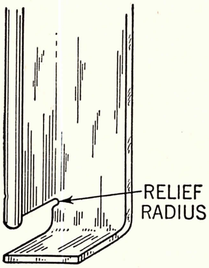
The instructions for repair should be obtained from an authorized person.

Where at the end of a bulb angle the bulb has been cut back to permit the bending of the flat surface, a relief cut is made at the point of radius bend (see Fig. 37). This relief is important, for it prevents the cracking of the material at that point during or after the bending operation.

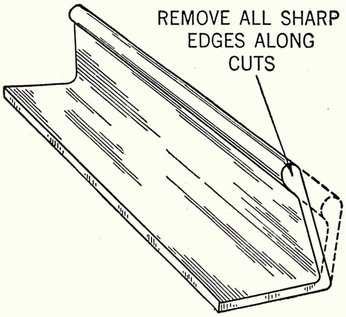


VIEW OF COUNTER PUNCH
(Enlarged)
FIG. 36.

When a bulb angle has a taper at its end, it is accepted practice to remove all sharp edges along the surfaces that have been cut (Fig. 38). All surfaces exposing the bare metal of such a bulb angle are touched up with approved paint.



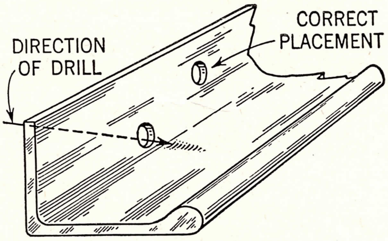
BULB ANGLE
FIG. 37.



BULB ANGLE
FIG. 38.

13.5. Damage Caused by Drilling. Occasionally a bulb angle is damaged by a drill that has cut across the metal owing to its being held at an offside angle or to the hole being located too near the base radius of the bulb angle.

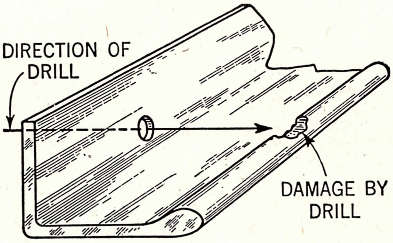
If the cut along the metal is in the nature of surface damage (see Fig. 39), this is usually corrected by authorized burnishing of the rough edges, followed by a touching up with paint.



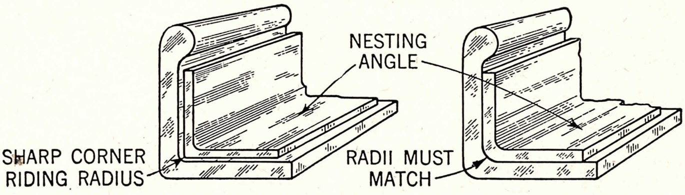
BULB ANGLE
Fig. 39.

In the event the damage sustained is excessive, authorized repair instructions are required. These instructions may require (1) replacement or (2) nesting an angle of suitable material, type, and size into the section of the damaged bulb angle (Fig. 40).

13.6. Nesting an Angle into Another Angle. When it is required to nest one angle into another, the one located on top and inside of the other angle should have its sharp corner along the angle base corrected, so that its outside radius will match the inside radius of the original angle. After removing material as necessary, the bare metal is covered with an application of an approved paint coating (see Fig. 41).



BULB ANGLE
Fig. 40.



INCORRECT CORRECT
Fig. 41.

13.7. Clearance on Longitudinal Cutouts in Frames. Where longitudinal bulb-angle stringers pass through cutouts in frames, it is necessary that they have clearance; otherwise, danger exists of fracturing the frame material (see Fig. 42). To correct unsatisfactory clearance conditions, it is necessary to remove the stringer angle temporarily and enlarge the cutout sufficiently to obtain safe clearance. Only the minimum amount of metal should be removed. All burrs and sharp edges resulting from the removal operation are cleared away, and the metal exposed is protected by painting it with an approved primer paint.

13.8. Plating (Skin Cover). During the fitting of outer skins, it becomes at times necessary to clamp the sheet to a support. Usually, small-sized C clamps are used for this purpose. It is good shop practice to place a piece of strong paper, tape, or other suitable material between the sheet and the screwhead. This precaution prevents radial cutting of the screwhead during the clamping up of the sheet (see Fig. 43).

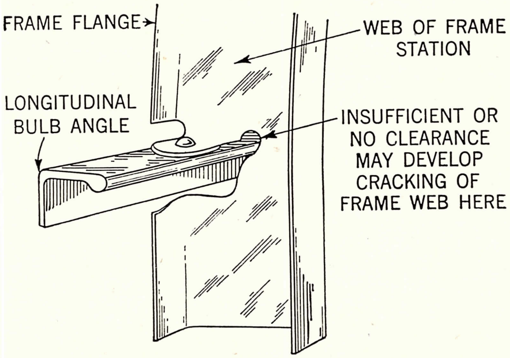

FRAME FLANGE
WEB OF FRAME STATION
LONGITUDINAL BULB ANGLE
INSUFFICIENT OR NO CLEARANCE MAY DEVELOP CRACKING OF FRAME WEB HERE

Fig. 42.

13.9. Fitting Skin Sheets. When a sheet is being fitted and it is necessary to mark trim lines, it is permissible to use a scribe, provided that the trimming operation will remove all traces of any scribe marks. Otherwise, a soft lead pencil is used, which does not scratch the surface of the sheet. This precaution is necessary to prevent cutting of metal which may result in cracking.

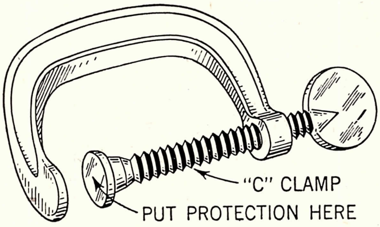


Fig. 43.

13.10. Drilling Skin Sheets. This operation requires attention and the correct use of tools. Inspectors should see that all personnel understand the following requirements:

1. Only sharp drills having cutting angles for the material being drilled should be used.

2. The sheets, or skins, should be supported on the opposite side of drilling; usually, a second man supports them with a wooden block during the drilling operation.

3. The drill should not be crowded, nor should too much pressure be applied.

4. If at the beginning a drill "runs off" and damages the surface of a skin, authorized instructions as to repair are necessary.

5. Should the surface on which such damage occurs be painted, the paint is removed over a sufficiently large area for investigation of the extent of the damage incurred.

6. The small burrs surrounding a hole where the drill comes through are removed prior to final installation.

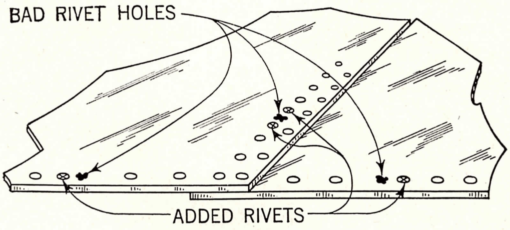


Fig. 44.

The alignment of the drill to the surface to be drilled is important, for enlarged or elongated holes will result from off-angle drilling. Ways of dealing with such holes are as follows:

1. If the enlarged hole is only slightly oversize, an oversize (next-size) rivet may be used, particular attention being paid to the edge distance available. The use of special rivets requires proper authorization.

2. Sometimes along a line of rivet holes one faulty hole is found. At times, not much can be done except at great cost, such as replacing a questionable section of plating. The usual correction in the case of a bad rivet hole is the addition of a rivet at the legal distance from the damaged hole. An additional rivet may be located either on only one side of the damaged hole, or on both sides (see Fig. 44).

Rivets installed in bad holes will have some strength, but to offset any such doubtful strength additional rivets are installed. These added rivets are of the same type and kind as the original ones.

When rivets are of the flush type, the preparation of surfaces must meet a certain standard of workmanship. On mechanical countersinking operation the following points should be noted:

1. The direction of the countersinking must be at 90 deg. to the surface being countersunk (Fig. 45).

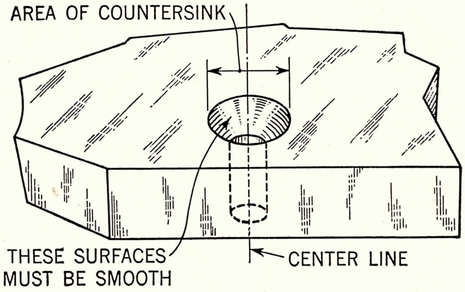


FIG. 45.

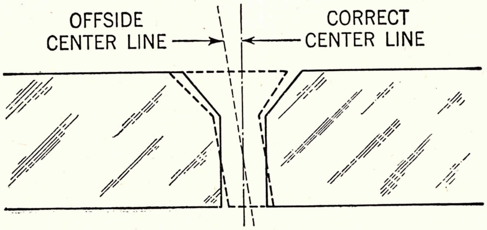


FIG. 46.

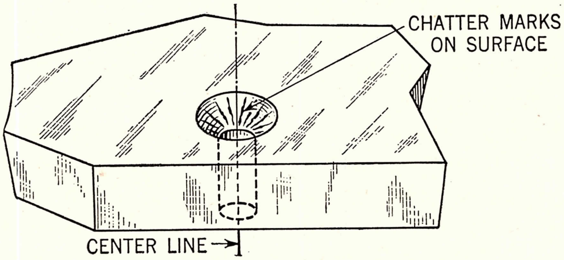


FIG. 47.

2. Figure 46 shows the result of countersinking at an off angle. In such cases, a rivet cannot be installed correctly.

3. The tool used in the countersinking operation should be of correct angle and should have sharp cutting edges. If the tool is not sharp, chatter marks will result (Fig. 47). Chatter marks

reduce surface contact and therefore should be eliminated. The surfaces of contact should be as smooth as possible.

13.11. Cracks. The usual corrections for small cracks in aluminum and its alloys are described in the following paragraphs. Attention is called to the necessity of *first obtaining proper authorization* before the corrections described may be undertaken. There are several ways of dealing with cracks, which may be described as follows:

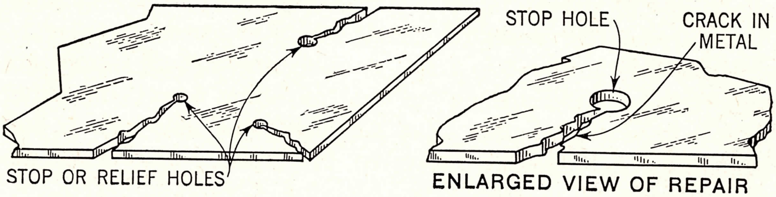


Fig. 48.

1. A crack may start in the metal and extend to the end of the metal. To prevent the cracking action from spreading into good metal a practice has been established and accepted of drilling a stop hole of suitable size at the point where a crack has its start. The purpose of such a hole is to stop the crack from traveling on, especially under the influence of vibration. The size of the stop hole should be large enough to provide sufficient relief for adjacent surfaces (see Figs. 48, 49, and 50).

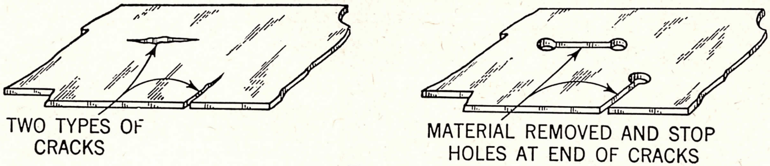


Fig. 49.

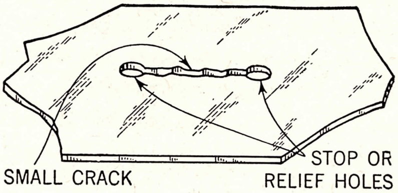


Fig. 50.

2. In some cases, it may be advisable to "clean out" some of the metal around or between cracks. This is done to prevent

rubbing or scraping contact between the edges along a crack and the consequent formation of new cracks from these edges. A stop hole or holes are drilled first, and then the metal is removed, as shown in Fig. 49.

13.12. Small Damages to Skin Sheets. Occasionally, small, sharp bumps are found during the inspection of the plating. These are usually caused by small parts, such as screws or rivets.

If the skin is about to crack through, these small bumps are corrected by drilling them out and installing a soft aluminum rivet. Any small bumps that are rather flat and have a dull point may be carefully corrected by expertly reworking the affected area.

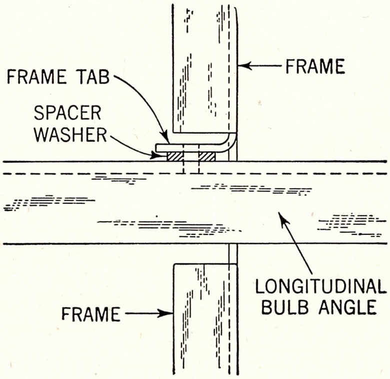


Fig. 51.

If a bump is large, authorization for installing a doubler is required.

13.13. "Oilcans." At times a section of skin, or plating, on the outside of a fuselage develops what is termed an "oilcan." This means that the skin in this area buckles in and out when pressure is applied. Proper authorization is required to correct such a condition. The correction of such a condition usually is made by installing stiffener angles as directed by authorized repair instructions.

13.14. Scratches. In dealing with scratches, it is important to analyze conditions surrounding the scratch, such as location, gage of material involved, and type of material. Consideration must always be given to the amount of vibration and corrosion to which the material will be subjected. Proper authorization is required for correction of scratches, and no repair should be made until such authorization is obtained.

13.15. Frame Tab Not Aligning with Longitudinal Stringer. Occasionally a frame tab will not match the alignment of a longitudinal stringer. It is shop practice to install a washer between the frame tab and the bulb-angle stringer (see Fig. 51).

13.16. Conclusion. The inspection personnel can be of great assistance to production by cooperating in the problems described in this chapter. Quick disposition of these problems is important in present-day production.